

Explorers, institutions and outside influences: botany north of Thursday

D. G. Frodin

Academy of Natural Sciences of Philadelphia, Nineteenth and the Parkway, Philadelphia, Pennsylvania 19103, U.S.A.

Abstract

Although collections had been made in coastal areas by several expeditions before 1840, botanical investigation of Papuasias on a larger scale began only in the 1870s. Until after World War II it was almost entirely in a primary phase, characterised by exploration, documentation and description, and very much influenced by individual interests as well as prevailing patterns of interior penetration, administrative control and official support. The size of New Guinea and the extent and interest of the region's flora, particularly in the mountains, were such that botanists and collectors ventured there from many countries, including, especially in the late 19th century, several from Australia or under Australian sponsorship. After 1900, however, Australian contributions fell sharply and up to 1941 most undertakings originated in metropolitan countries north of the Equator or in the Indies. Although no one nation was, or could be, dominant, the gap left by the end of German exploration after 1914 has attracted much comment. A growing dispersion of resources and publications, first seriously noted in the 1930s, was effectively tackled by Dutch botanists who were then well placed for this task. Their work of integration, aided by colleagues in other countries, has continued through *Flora Malesiana* and related publications but is far from completed and has been made harder by the loss of resources at Berlin-Dahlem in 1943. The end of the primary era may be marked by Brass's vegetation survey of 1941 and the start of *Flora Malesiana*.

From 1945, with domestic renewal in Australia, the expansion of science and higher education, and increased economic and political commitments to dependent territories in Papuasias, opportunities for local development of the sciences greatly improved. Australian involvement in Papuasian botanical work increased and diversified, both through the new Division of Botany in Lae and by contributions from CSIRO, ANU and others. Basic primary activities continued, leading to a doubling of available collections by the mid-1970s, and were joined by expanded efforts in geobotany, plant protection, plant biology, and ethnobotany. This second phase may be said to have ended with publication of J. Linsley Gressitt's *Biogeography and ecology in New Guinea* (Gressitt 1982).

Independence in Papua New Guinea and the Solomons coincided with the emergence of a pattern of lower economic growth both in the region and in Australia. Support for botany has again fallen for this and other reasons, including changing government priorities and poor organization of the sciences. While many useful publications have appeared, they reflect no long-term plan. A major flora project was initiated in the 1970s but it is something of a 'dream edifice' and its future appears very uncertain, with only two volumes published. Without new initiatives botanical work in Papuasias is likely to remain at a low level for some time.

Contents

Introduction	194
I. Exploration	194
A. Early history: glimpses of riches	194
B. First fruits: European entry & expansion, 1871–1883	195
C. British New Guinea, 1883–1918: the fragility of support	197
D. German New Guinea, 1884–1914: a flash of brilliance	198
E. Eastern New Guinea, 1914–1942: private progress	199
F. Western New Guinea, 1875–1942: the rising Dutch presence	201
II. Institutions	204
A. World War II: the awakening	204
B. The 'New Guinea Forces' (NGF) collections ...	205
C. Postwar development in P.N.G. and the Division of Botany	205
D. Other botanical centres in Papuaia	207
E. Metropolitan visitors	208
F. 1975 and beyond: changing scenes	210
III. Conclusion	212
Acknowledgements	212
References	212

Introduction

As with the protagonists in Jon Cleary's 1960 novel *North from Thursday*, the most lasting impression one forms after a study of the history of botany in New Guinea is of a mosaic, in which Australians were but one of many elements. To the immense and still poorly documented lore of the many tribal nations has been added, through the work of men and women from diverse outside lands, a patchy formal understanding of Papuan plant life.

Although the visitors perforce have dominated organized study, the 812,000 km² of the second largest island in the world and its satellites, some not small, were too large and varied (and for long too impenetrable) ever to be the exclusive preserve of a single country. New Guinea (and, by extension, Papuaia) provides, as not many other parts of the world can, an opportunity for comparing the aims, efforts and results of scientific expeditions and other forays from many countries, and for examining the growth, when it did come, of a resident botanical community.

Sustained botanical exploration began relatively late, as did serious efforts to bring about consolidation of scattered knowledge, a task which began in the 1930s and still continues. Basic plant inventory, description and classification dominated for the first eighty years. Only from the 1950s was there an extensive development of other areas of plant biology along with interdisciplinary fields such as vegetation history and Quaternary studies. Even so, the groundwork is far from complete, and deeper levels of botanical thought are yet little explored (cf. Stevens 1989). Existing surveys (Paijmans 1976; van Royen 1980; Gressitt 1982) are, and can only be, samplers.

A major part of any consolidation and development programme should be the bringing together of the historical record. For the natural sciences generally, August Wichmann's encyclopaedia *Entdeckungsgeschichte von Neu-Guinea* (Wichmann 1909–1912) was an important start. This was added to by several scholars in W. C. Klein's *Nieuw-Guinée* (Klein 1935–1938). For botany we have the brief overall surveys by White (1922), Lam (1934, 1935) and Womersley

(1953) in addition to the important *Malaysian plant collectors and collections* and its supplements by M. J. van Steenis-Kruseman (van Steenis-Kruseman 1950–1974). More specialized area or subject reviews, as well as gazetteers, have begun to appear only in recent years (e.g. Vink 1965, van Royen 1980, Croft 1983, Veldkamp, Vink & Frodin 1988).

Analyses, however, have so far been relatively few. Following my contribution to a narrative survey (Frodin & Gressitt 1982) I recently made an attempt to examine the history of exploration in Papuaia in terms of the natural sciences as a whole (Frodin 1988). Among my conclusions was that a principal motivation for sustained natural history exploration, when it did come, was the search for birds of paradise and bower birds and other novelties. Botanical exploration in its own right, with the exception of Rudolf Schlechter's tours of German New Guinea and Lilian Gibbs's pioneer vegetation studies at the Angi Lakes in western New Guinea, began only after World War I. Prior to then plant collecting and study was largely the province of organized general expeditions on sea and land, interested naturalist-explorers such as Alfred Russel Wallace, Odoardo Beccari, Luigi d'Albertis, Henry Ogg Forbes and Carl Lauterbach — and some resident officials, planters and missionaries.

The pioneer expeditions and individual naturalists naturally had support from interested advocates and sponsors, mostly in Europe. Among the most zealous, however, was Ferdinand von Mueller, then Government Botanist of Victoria. Along with many others, he was caught up in the 'New Guinea fever' which began to sweep Australia from the late 1860s as thoughts of new frontiers and concern over foreign activities took hold (Macmillan 1957). As a result, Australians were involved in collecting almost from the beginning of sustained New Guinea exploration in the 1870s. In this paper I shall concentrate on the botanical record, mainly from 1871, with emphasis on the Australian involvement.

I. Exploration

A. Early history: glimpses of riches

Although the Englishman William Dampier is usually credited with the first known botanical observations in Papuaia, made in 1700 on his voyage in the *Roebuck*, the plant life of the region was not in fact entirely unknown. Taxonomic revisions are gradually showing that many species, particularly of low- and medium-altitude trees, were actually first recorded in the Moluccas by that seventeenth-century 'Plinius indicus', Georg Eberhard Rumpf. But the late publication of his *Herbarium amboinense*, the difficulty in interpretation of many of its illustrations in the absence of associated collections, assumptions about plant distribution, and other factors all contributed to the development of a 'separate' Papuan taxonomy, particularly east of Dutch territory.

Dampier's few records were added to fairly extensively during the late eighteenth and early nineteenth centuries. These, however, rested almost entirely on the work of short calls by exploring voyages — the then-Lt. James Cook stayed only a day, early in September 1770 — at a small number of points. While the

French made the most visits, only the materials of Alexander Zippelius, who as a member of the Indies Natural Sciences Commission stayed two months in 1828 at the pioneer Dutch settlement in Triton Bay, materially increased knowledge of the land flora. As published by Carl Blume in his serial *Rumphia*, they were used by Friedrich A. W. Miquel in his *Flora indiae batavae* (Miquel 1855–1859) — and especially the Swiss botanist Heinrich Zollinger, who postulated for the lowland flora a relationship with what he called the ‘flora Malesiana’ (Zollinger 1857) — to make some first, very tentative conclusions about the New Guinea flora and its relationships. But about the extensive mountainous regions Zollinger and others could only speculate. Until the 1870s and the advent of sustained inland exploration these inaccessible areas would remain botanically unknown.

B. First fruits: European entry and expansion, 1871–1883

This period covers the rise of a wide European and Australasian interest in New Guinea, its first climax in 1875, decline, and subsequent renewal as geopolitical developments influenced the issue of the island’s future.

I have elsewhere described (Frodin 1988) some of the developments which led up to the great increase in activity by naturalists in New Guinea. Among significant pressures which would break down the region’s isolation were the growing dependence of the expanding world economy on the production and transportation of natural products and plantation crops, increasing competition of the great European powers in the Pacific, and the emergence of Australia as a force in its own right. Calls began to be heard, both in Europe and Australia (Lang 1871), for opening up the country to white settlement.

Natural history also played a key role. What seems to have been an effective catalyst in the opening up of New Guinea was the still-current interest in natural history ‘novelties’, among them orchids and other ornamental plants, not to mention animals and plants of actual or potential economic value, including, notably, bird-of-paradise plumes. But at the beginning of the 1870s New Guinea was still rarely visited and access for scientists difficult. Travel on naval vessels was sometimes possible — the Italians Luigi d’Albertis and Odoardo Beccari, and the Russian Nikolai Miklucho-Maclay, between them probably most responsible for stimulating a sustained interest in New Guinea natural history, were able at times to enjoy this privilege — but such movement was dependent on political and strategic perceptions. Local suspicion of unusual activities prevailed. Most naturalists, and particularly botanists, were perforce dependent on the spread of formal economic and mission activity or were ‘added on’ to voyages and expeditions made for other or more general purposes.

The three intrepid individuals just mentioned were from countries with little or no prior involvement in the Southwestern Pacific. Their decision to go to New Guinea was for scientific reasons. Doubtless they were influenced by the English naturalist Alfred Russel Wallace’s recently-published *The Malay Archipelago*, a work which ever since has inspired young naturalists

to visit the ‘eastern tropics’. But the explorers’ respective mentors, Giacomo Doria in Genoa and Karl von Baer in St Petersburg, also knew it was a new frontier. And they were not disappointed: from Andai (south of Dorei Bay), d’Albertis and Beccari entered the ‘forbidden’ mountains for the first time in September 1872. Beccari was to return twice more, alone, in 1875–1876.

Beccari, d’Albertis and, to a lesser extent, Maclay nevertheless were viewed with suspicion (Goode 1977) — although Beccari later allayed any fears. Along with other developments, such as alleged Italian and German colonization schemes and the arrival of British missionaries in the Torres Straits, such foreign travellers induced the Dutch to increase their presence in western New Guinea. Further east, the British became concerned about the growth and management of the Queensland labor trade, stepping up naval patrols in Melanesia from their Sydney station, and increasing trade through the Torres Straits and China Strait (at the eastern tip of New Guinea). The Australian colonies also began to be concerned about security on their northern frontier, as well as the activities of Russia and other powers in the Pacific.

The Dutch response took the form of a series of naval patrols. To this end, on 12 August 1871 their ship, the *Dassoon*, sailed from Ternate on the first of several voyages. With this voyage, the Dutch may be credited with the initiation of serious and sustained plant collecting in New Guinea. On board was the veteran Buitenzorg (Bogor) plantsman, Johannes Teysmann — the first Dutch botanist to visit New Guinea since Zippelius.

While the fruits of this voyage of some three months were relatively modest, Teysmann obtaining only 133 species, they were a beginning. As Teysmann himself had done, Wichmann (1909–1912, vol. 2, p. 150) criticized this voyage for providing few collecting opportunities. But, in his 1876 report on the plants, the director of the *’s Lands Plantentuin* in Buitenzorg, Rudolph Scheffer, also incorporated earlier Dutch and French material. Among the latter were the records of Pierre-Adolphe Lesson made at Dorei Bay (on which the town of Manokwari now stands) in 1827 on Capt. Jules Dumont d’Urville’s *Astrolabe* world voyage and published by Achille Richard as part of his *Sertum astrolabianum* (Richard 1834). A consolidated list of known western New Guinea plants at last existed, although Beccari’s collections were not included and in another generation it would be out of date.

Scheffer also sent a good set of Teysmann’s specimens to Ferdinand Mueller in Melbourne — perhaps thereby quickening his, and Australia’s, interest in the New Guinea flora. Mueller, having been a member of the 1855–1856 North Australian Expedition of Augustus C. Gregory, was already aware that the flora of northern Australia differed in many ways from that of the south, and New Guinea and the islands of the Pacific were an extension of this awareness.

D’Albertis, and later Maclay and Beccari, would also turn to Australia for support. D’Albertis, recovering from illness in Sydney in 1873, had the good fortune there to befriend the noted local naturalist Dr George Bennett. Like Mueller, Bennett was a strong advocate of New Guinea exploration and subsequently lent his support, which for the Italian’s

subsequent, more famous ventures proved vital (Goode 1977). Macleay also developed extensive contacts in Australia. Their work there did much to increase Australian interest in the natural world of New Guinea, of which plants were part.

Mueller, the most prominent botanist in Australia, unfortunately never would, or could, go himself, and it was not until 1898 that an Australian botanist reached New Guinea. From late in 1875, however, he would begin to receive a continuous flow of Papuan plants at his 'Phytologic Museum' (now the National Herbarium of Victoria). Until his death in October 1896, nearly all plant collectors in eastern New Guinea, the New Britain (later Bismarck) Archipelago and the Solomons sent him their specimens, or good duplicate sets thereof. But of primary collections all were from amateurs, non-specialized naturalists or others, mainly Australian or British. The few professional botanists to reach New Guinea before 1898, including Beccari, worked up their collections in Europe. Enough arrived at Melbourne, however, for Mueller to publish over sixty papers on Papuan plants.

In his first paper, Mueller acknowledged the growing public interest in New Guinea as a new frontier: 'a large island-country . . . stretching moreover into close proximity of the Australian Continent, must be to us here of special importance for commerce and colonisation . . . particularly at a time when the settlement along the opposite Australian coast is effected' (Mueller 1875, p. 3). This interest — termed 'New Guinea fever' both by Macmillan (1957) and Goode (1977) — had arisen at the end of the 1860s. In spite of some setbacks, interest was further heightened by favourable reports by Captain John Moresby who, from 1872 to 1876, undertook in the *Basilisk* a series of coastal surveys for the Royal Navy and who, early in 1873, 'discovered' the fine harbour on the south-east coast from whose shores Port Moresby now spreads (Moresby 1876; Thompson 1980, pp. 36, 39). These pressures culminated in a general meeting in Sydney in May 1875 which advocated annexation. Similar sentiments were voiced elsewhere in Australia. A few voices, however, urged caution. Among them was the editor of the *Sydney Morning Herald*, Andrew Garran, who, on the eve of the first serious Australian-sponsored expedition to New Guinea, wrote that 'English talent does not seem to lie in the direction of civilising inferior races' (Thompson 1980, p. 41).

The New Guinea expedition, however, had been organized for very different reasons. Personal, public and indeed proto-national interest had led William J. Macleay, nephew of the one-time Colonial Secretary Alexander Macleay and last of the naturalists in the Macleay family, to conceive early in 1874 the idea of an Australian scientific voyage. Following the visit of the British *Challenger* expedition in 1874 (and which would be in New Guinea waters late that year and early the next) Macleay resolved to go to New Guinea. Inspired by the work of the *Challenger* he planned the expedition mainly around collecting and research in marine biology and oceanography. Botany, however, was partly covered by two gardeners from his friend Sir William Macarthur's estate at Camden Park, one of them being J. Reedy who would assemble a small herbarium. For a ship he purchased the barque *Chevert*,

an old French naval vessel which had seen long service in the Pacific, including convict transport (Macmillan 1957) and had her refitted.

The departure of the expedition, just days after the above-mentioned Sydney meeting, inevitably involved it in the political debate over New Guinea. Many annexationists may have thought that the voyage was connected with their movement; so had d'Albertis (Macmillan 1957, p. 150). But Macleay, it should be noted, was an opponent of unrestricted outside exploitation (Grattan 1963) and his hurried and apparently ignominious return by steamer in October 1875 — the *Chevert* followed later from Cape York — effectively 'killed off' an already waning colonization craze (Thompson 1980, p. 43). Fever, the greatest scourge of New Guinea, had stricken down Macleay off Yule Island late in August.

Although quite productive for marine biology — and thus for Macleay a success — the *Chevert* voyage was less so in matters geographical or botanical. Macleay never reached his main objective, the Fly River, and the gardeners concentrated on living plants (Macmillan 1957, p. 137). Nevertheless, the some 125 specimens obtained by Reedy included two species of *Eucalyptus*, one new, and such plants common to both Australia and New Guinea as *Dischidia nummularia*, *Elaeocarpus arnhemicus* and *Exocarpus latifolia*. The eucalypt discoveries, along with Beccari's 1872 finds of oaks [actually chestnut-oaks of the genus *Lithocarpus*] and other species with Asian affinities in the northwest, and the collections before the 1840s which pointed to an essentially Malesian flora, set the stage for the enduring interest of New Guinea in the study of plant biogeography. In the introduction to the first part of his series *Descriptive notes on Papuan plants*, Mueller called the flora a 'blending . . . of Australian forms . . . with Sundaic types of plants', noting that it would 'render to an Australian naturalist the study of the Papuan vegetation one of great significance' (Mueller 1875, p. 4).

The British government refused to sanction annexation of New Guinea and until the 1880s no more large-scale exploring expeditions from Australia would be mounted. Naturalists would have to be resident or find private or institutional sponsorship; the difficulties of terrain, climate, and human contact increasingly made it clear that serious efforts would require official backing. Mueller's fascination with New Guinea would remain, however. He had already interested the Congregational missionaries in New Guinea, beginning with Samuel Macfarlane, in collecting and in 1876 he received plants from d'Albertis and the commercial traveller Andrew Goldie. He also received some lots from New Britain, as we shall note later. The results filled four more issues of his *Descriptive Notes* as well as several other papers. Among them were descriptions of such fine plants as *Mucuna bennettii* from the Fly River and *Combretum goldieanum* from Port Moresby, along with further evidence for the close connections between the floras of New Guinea and northern Australia, particularly in the Trans-Fly area. But only with the entry of organized government into New Guinea would a 'particular charm' of Mueller, the comparison of its alpine flora with those of Australia [and New Zealand], be realized (Mueller 1876, p. 52).

C. British New Guinea, 1883–1918: the fragility of support

Renewed political pressures respecting New Guinea were felt from the early 1880s. It culminated in a unilateral annexation proclamation by Queensland on 4 April 1883 at Port Moresby and covered all non-Dutch territory. Though disallowed in London, this move eventually led to partition of eastern Papuasia and the establishment in November 1884 of organized administration, respectively German in the north and British, with Australian support, in the south.

Queensland's move, along with investigative reporting by the Melbourne newspapers *Age* and *Argus*, further raised interest in New Guinea. Geographical societies were formed, which with official and private support mounted a number of expeditions over the remainder of the decade, e.g. the 1885 *Bonito* expedition with botanist Wilhelm Bäuerlen (Wilson, this volume). These and work by private collectors renewed the flow of specimens, including plants for Mueller. In 1885 Mueller resumed publication of *Descriptive Notes*.

Two early administrators of British New Guinea had a scientific background. General Sir Peter Scratchley, in office during 1885, had been a military engineer in Australia. Sir William MacGregor, in office from 1888 to 1898, began colonial service as a medical officer. The former gave considerable assistance to Henry Ogg Forbes — a geographer-naturalist sponsored by the Royal Geographical Society and its sister bodies in Australia — on his arrival in the territory and visited Forbes's base camp on the Sogeri Plateau. MacGregor (partly in answer to criticisms of the various privately and semi-privately sponsored expeditions, notably that of Forbes which was seen as geographically unsuccessful) made natural history collecting a government responsibility. He assigned the work to designated officers, and undertook numerous expeditions and patrols, including Mt Victoria (in 1889) and other peaks in the Owen Stanley and Wharton Ranges. He also attempted to set up a botanical garden and begin investigations of potentially useful native plants, of which only one, *Ficus microcarpa* var. *rigo*, enjoyed any success.

An early fruit of MacGregor's work was a botanical collection from Mt Victoria — the first from any alpine region in New Guinea. Mueller, his 'particular charm' fulfilled, promptly wrote it up as *Records of observations on Sir William MacGregor's highland plants from New Guinea* (Mueller 1889). Mueller subsequently published scattered papers on further collections from MacGregor and others. But it was too much for one man with many other responsibilities — and insufficient resources, particularly at a time of economic depression in Australia. Indeed, at the time of his death Mueller reputedly had described 'only a small part of the Papuan material' which he had assembled (van Steenis-Kruseman 1958, p. [13]).

Particularly serious was failure to publish a full account of the Forbes herbarium, although its monocotyledons were early studied (Ridley 1886) and Mueller described a number of the more notable dicotyledons. Apart from the alpine plants, this collection was the most important of the period, comprising over 1,000 numbers from a hill region never before visited. But, due to misunderstandings with William

Carruthers, then Keeper of Botany at the British Museum (Natural History), and changing interests on the part of Forbes neither of his two major collections — the other being from Java, Sumatra and Timor — was fully reported on until the 1920s (Rendle *et al.*, 1923, 1924–1926). The Museum did, however, become an important repository for New Guinea plants with its acquisitions of the Boden Kloss and Carr collections, which will be mentioned later.

Beccari also never completed study of his collections. Although appointed director of the botanical garden and herbarium at Florence in 1876, and having organized his serial *Malesia* (Beccari 1877–1890), he later took issue with some plans for development and administration of the herbarium (van Steenis 1982) and then withdrew from botany for several years. He returned as a specialist in palms and made important contributions to knowledge of the New Guinean species. His other plants, vascular and non-vascular, were largely described by specialists.

Following Mueller's death, MacGregor arranged to have his last large collection, from the higher parts of the Wharton range, identified at Kew. This soon appeared as *Flora of British New Guinea* (Hemsley *et al.* 1899). But it was to be for decades Kew's only major contribution to New Guinea systematic botany, its staff under William Thistleton-Dyer and for long afterwards being most concerned with Africa. In 1898, shortly before the end of his New Guinea service, the by-then Lieutenant-Governor arranged with the Queensland Government that Frederick Manson Bailey, their Colonial Botanist, should assume responsibility for botanical services to British New Guinea. Bailey visited the colony in that year on a tour of inspection with Governor Lord Lamington, the first by a professional botanist from Australia. He was, however, never able to contribute more than minimally, having few resources and being always more than fully preoccupied with Queensland affairs.

Bailey, however, was not the first Queensland biologist to visit the area. In 1895 Henry Tryon, a naturalist and entomologist who shortly before had joined the Queensland Department of Agriculture, collected sugar-cane varieties. Several, especially 'Badila', were to be very useful to the Queensland sugar industry (Steenis-Kruseman 1950, p. 533; Bolton 1972, p. 239). More germplasm expeditions, for sugar and other crops, would follow in the twentieth century.

Local government efforts in the natural sciences, including plant collecting, rapidly declined after MacGregor's departure and remained so for several decades, save in a few areas directly related to the economy. Although Lieutenant Governors George R. le Hunte and Francis R. Barton contributed some collections for Bailey, most of what little work was done from 1898 to 1918 was under private auspices. The most substantial lots received by Bailey were from Mrs Mary Schlenker and Copland King. Schlenker, of Brisbane, and the wife of a Congregationalist missionary, collected in inland parts of the Rigo District. King, of Sydney, was a founder in 1891 of the Anglican Mission in New Guinea. He specialized in orchids and pteridophytes from that mission's field in present-day Oro and Milne Bay Provinces.

Some of King's material also reached Sydney, where Joseph Henry Maiden had, from the mid-1890s, been

energetically developing the herbarium at the Royal Botanic Gardens. Maiden also was able to attract other Papuan collections, including some from F. H. Brown collected on the Varirata Plateau near Port Moresby (forwarded through his employers, Burns, Philp & Co. of Sydney) and Richard Parkinson in New Britain, who earlier had sent material to Mueller. But, in spite of his acquisition of these and other valuable extra-Australian resources, Maiden, like Bailey, had little or no opportunity to develop a sustained interest in floristic work outside his State.

The advent of the Federal government brought few new initiatives for support of scientific work in New Guinea — not surprisingly for a body which was only gradually establishing itself and lacked resources or a tradition for sustained support of the sciences. In botany, criticism by Colonel Kenneth Mackay, writing for the 1906 Royal Commission on British New Guinea (Australia 1907, p. lxiv) and, shortly afterwards, a lengthy submission by Maiden, with proposals to the Chief Secretary (Maiden 1923), elicited no response. Until World War II the Commonwealth made no really significant direct contribution to New Guinea botany save for its sponsorship of Charles E. Lane-Poole's forest survey of 1922–1924. A 1908 survey, on behalf of the Department of External Affairs, by Gilbert Burnett, a Queensland forest inspector, was botanically unproductive (White 1922, p. 11).

All these problems were symptomatic of what was essentially an ephemeral interest within the countries from which the explorers and naturalists of the 1870s and 1880s had chiefly come. Resources could no longer be spared for New Guinea once initial curiosity had been satisfied and decisions of state made. Without such support, the economy and administration of British New Guinea, and later Papua, could support only the barest minimum of scientific work. It is to MacGregor's credit that he accomplished as much as he did, but in the absence of dedicated metropolitan assistance neither Mueller, Bailey, the British Museum or Kew could undertake effective consolidation of botanical knowledge. In any case Kew was shifting responsibility for some of its work to the 'periphery' (Broekway 1979). Greater centralization of major collections and a different approach to science and development in their colonies would soon give the Germans, and later the Dutch, a significant overall 'lead' in New Guinea botany which they enjoyed for a quarter-century and beyond.

D. German New Guinea, 1884–1914: a flash of brilliance

The advent, from November 1884, of a formal German presence in northeastern New Guinea and the nearby major and minor islands of the renamed Bismarck Archipelago and the northern Solomons, brought in an increased effort in natural history. Previous German contacts with the region had been sporadic, although increasing from the 1870s. In 1875 came the first major German expedition to the region, on its world cruise in the warship *Gazelle* under Capt. G. E. G. Freiherr von Schleinitz. The botanical collections, made by the ship's surgeon Friedrich Naumann, were written up by the still relatively-young Adolf Engler, then at Kiel University, and other specialists. But Germany, and above all, the Royal Botanical

Museum in Berlin, was not to build up its celebrated New Guinea holdings until after annexation. The contributions of the individual Germans who followed the entry of mercantile enterprise, such as Carl Walter, Ernst Betsch, and, after his settlement in the area in 1882 as a planter, Richard Parkinson — though relatively modest and perforce nearly all from coastal parts of the Bismarck Archipelago — mostly flowed to Melbourne, like those from the future British New Guinea. Only the naturalist (and intelligence agent) Otto Finsch, better known as an ethnographer, zoologist and geographer, sent his reportedly few plant collections 'home'.

The picture changed sharply after annexation of the area and the foundation, beginning in 1885, of Finschhafen and other stations by the New Guinea Company. The Company, under the direction of the Berlin banker Adolph von Hansemann, in its early years invested heavily in exploration. Botany progressed in concert with other activities, and the mounting of the New Guinea Expedition of 1886–1887 under the leadership of Carl Schrader to look at the virtually unknown interior included a young botanist, Udo Max Hollrung. This expedition, though not entirely fulfilling instructions or expectations (Wichmann 1909–1912, vol. 2, p. 413, 455), set an important precedent: exploration was to be carried out primarily for science and development and not, as in British New Guinea, with pacification, control and the introduction of native administration as the main aims. The Germans 'walked less but recorded more' (Firth 1982, p. 161). Over the next decade and a half, with the work of various expeditions and individuals, botanical knowledge of German New Guinea, in terms of numbers of specimens collected, caught up with British New Guinea by 1900 — even though to some contemporary observers scientific exploration seemed to be lagging (Mackellar 1912, p. 178). Following publication of *Die Flora der deutschen Schutzgebiete in der Südsee* and its *Nachträge* (Schumann & Lauterbach 1901, 1905), and especially after 1907 when, with the advent of a separate Colonial Office and representations by Governor Albert Hahl additional support became available for the colony, progress became even more rapid. Additional collecting (particularly by Rudolf Schlechter, Carl Ledermann, Karl Rechinger, Leonhard Schultze-Jena, the Rev. Christian Keysser, and Rev. Father Gerhard Pöckel), the production of Schlechter's *Die Orchidaceen von Deutsch-Neu-Guinea* (Schlechter 1911–1914, 1982) — for which he will be long remembered (Timler & Zepernick 1987, p. 151) — brought in as many as 15,000 specimens in seven years. The initiation (in 1912), under Carl Lauterbach's direction and with the support of a private foundation, of the series *Beiträge zur Flora von Papuasien*, published in Engler's *Botanische Jahrbücher für Systematik*, provided a major outlet for systematic revisions. By 1914 German botanists were well ahead of those of Australia or, indeed, of any other country.

Contemporary writers took note of the disparity in knowledge. Carl Lauterbach (Lauterbach 1911, p. 22), not without some German pride, remarked: 'Was zunächst Englisch-Neu-Guinea anbetrifft, so ist daselbst in der letzten Zeit für die botanische Erforschung nur sehr wenig geschehen' — a sharp change from the era of 'der ... hochverdiente Gouverneur'

MacGregor. Only the Dutch were, as he acknowledged (and as we shall see below) — 'vom 1903 ab beginnt jedoch eine lebhaftige Tätigkeit' — catching up in consequence of their major exploration programmes and, from 1909, publication of *Nova Guinea*. By 1916 Ridley was to write in his *Report on the botany of the Wollaston Expedition to Dutch New Guinea, 1912–13*: 'The flora of British New Guinea has been more neglected than that of Dutch and German New Guinea; except for Forbes's collections on the Sogeri Mountains, which have not yet been fully worked out, and a small lot obtained by Macgregor and Giulianetti, no collecting of importance has been done there' (Ridley 1916, p. 2). This comment, however, clearly took note only of results published in British journals. Mueller's contributions were considerable, if scattered, and the mass of material which he accumulated in Melbourne would represent a valuable, if imperfect, future resource for the British New Guinea flora.

Beside work and publications noted above, German scientists (and contemporary visitors from other countries, among them the Swede Erik Nyman and the Hungarian Lajos Biró) were also responsible for confirming the predominantly Malesian character of the lowland flora over most of New Guinea (Warburg 1891, 1892); the initiation of serious collecting of bryophytes (one of the leading moss specialists of the day, Max Fleischer, visited in 1903) and other non-vascular cryptogams, fungi and lichens (fully accounted for in Schumann and Lauterbach's volumes); a vegetation map and zonation scheme (Lauterbach in Meyer 1910); economic botanical studies (by Kacrnabach, Warburg, and Schlechter among others); the establishment of a botanical garden (in 1906, in the new town of Rabaul); the first exploration of Bougainville Island (cf. Reehinger & Reehinger 1908); detailed local floristic work, firstly in the Gazelle Peninsula by Friedrich Dahl (Schumann 1898) and later there and in New Ireland by Father G. Peckel (Peckel 1985); a successful exploration of an alpine flora (by Christian Keysser, in 1912); and, thanks particularly to the work of Schlechter and Ledermann as well as Lilian Gibbs in western New Guinea (see below), a conscious sampling of a wide variety of habitats and, later, the idea that the [lower] montane flora was part of a pan-austral assemblage probably of great antiquity (Diels 1921).

The German contribution, which in the field ended in 1914 but continued long afterwards in publications, has been much praised and certainly far exceeded British and Australian efforts in southeastern New Guinea during the period, especially after 1900. Not unsurprisingly, however, it owes more to individual work than to official efforts, in view of the focus of German colonial interests (including the *Botanische Zentralstelle*, formed in 1891 at the Berlin Botanical Garden and Museum) on Africa (Timler & Zepernick 1987). That much was accomplished in New Guinea was to a goodly extent due to the personal efforts of Carl Lauterbach and Governor Hahl, not to mention the collectors in the field along with expedition leaders such as Walter Behrmann. Inevitably the impetus slackened and, while the *Beiträge* continued to appear until 1942, no *Die Pflanzenwelt Papuasiens* ever eventuated and German contributions to New Guinea botany would all but cease after World War II.

E. Eastern New Guinea, 1914–42: private progress

Soon after the outbreak of World War I, German New Guinea, after a brief struggle near Blanche Bay, fell to the Australian Naval and Military Expeditionary Force on 13 September 1914 and remained under military rule until May 1921, when it became a Mandated Territory of the League of Nations under Australian administration. Little botanical work was done during this period. Some collecting was done by the planter, Wilhelm Bradtke, in the Duke of York Islands and by the missionaries Gerhard Peekel in New Ireland and Christian Keysser (sometimes with the German surveyor and fugitive Capt. Hermann Detzner) on the mainland. By contrast, Papua, an external territory of Australia, enjoyed a new and more favourable period of botanical exploration beginning even before the end of the War in November 1918. This was due to continuity of the Australian administration under Sir Hubert Murray and the appointment as Queensland Government Botanist in that year of Cyril T. White, a grandson of Bailey and the first notable native-born Australian systematic botanist. White was for years interested in the rainforest flora of Queensland and, as 'consultant botanist' to the Papuan administration, he could extend this interest to New Guinea and the Solomons.

Official Australia generally was all but indifferent to extensive study and development of the New Guinea territories — save in terms of potential economic gain. It was only the personal policies and efforts of Murray which gave Papua its distinctively 'liberal' reputation in Australian and British colonial circles. Following a 1919 commission of inquiry, what became the Mandated Territory of New Guinea was, in 1921, effectively reorganized as a commercial colony. German interests were expropriated and positions and properties offered to returned Australian servicemen. Alexander (1972, p. 79) has argued that these factors were at least partly responsible for 'the poor quality of . . . government . . . during the postwar decade'. In Germany, Walter Behrmann, the former leader of the 1912–1913 Sepik Expedition who was now a geographer at the University of Berlin, would be critical of the precipitous fall in exploration and scientific work, noting also, as have some subsequent writers, that development and administrative control in some areas had actually deteriorated (Behrmann 1924). Charles Rowley, of the Australian School of Pacific Administration in Sydney, wrote in 1958 that 'the Australian administration seems to have been more despotic and repressive than its predecessor' (McKillop & Firth in Denoon & Snowden 1981, p. 100).

An exploring expedition was organized by the Commonwealth in 1921, using a small ship, the *Wattle*, to explore parts of the Mandated Territory with the aim of assessing economic potential. In particular, the team looked at the Ramu Valley which had first attracted German attention twenty-five years before. Although a forester, H. W. Haynes, accompanied the trip (Angus 1972, p. 448), no botanical material evidently was obtained. The following year, as part of forest resource investigations for the relatively new Australian Forest Service, the Commonwealth Inspector-General of Forests, Charles E. Lane-Poolc, undertook extensive surveys in both Papua (May 1922 to February 1923) and New Guinea (November 1923 to

October 1924). The resulting report, *The forest resources of the territories of Papua and New Guinea* (Lane-Poole 1925), is one of the classics of New Guinea botanical literature, including as it does the first extensive, well-illustrated review of the vegetation of eastern New Guinea. White, together with his Queensland Herbarium associate William D. Francis, identified the plants. Like Mackay and Maiden before him, Lane-Poole was critical of the decline in botanical exploration. He wrote (1925, p. 69) that 'it is a thousand pities that the systematic work so ably begun by Sir William MacGregor in 1889 in Papua should have been allowed to drop, and that no steps were taken to describe the flora of Papua until Mr White's visit in 1921 [actually 1918]. As for the Territory of New Guinea, the work of German scientists appears to have been wholly lost'. But official indifference continued, and until the mid-1930s private parties dominated botanical work in the Mandate.

The same lack of official concern was evident in the applied sector. A reputedly capable Director of Agriculture in the Mandated Territory, George Bryce, resigned, apparently frustrated, after less than three years (1923–1926). 'His scientific background and tropical experience rested awkwardly on Australian institutions' (McKillop & Firth in Denoon & Snowden 1981, p. 100). The contrast with the German era would also be noted by his successor, George Murray (Shurcliff 1929, p. 202). Lane-Poole's proposals for a Forest Service languished until 1938 when, in response to increasing local demand for timber and growing exports (particularly of New Guinea walnut, *Dracontomelum dao*; d'Espessis 1940), two foresters were appointed to the administration (Womersley 1953).

A positive legacy of the Bryce era was, however, his revival of the German plans for an experimental plantation in Keravat, realized in 1928 (now the Lowlands Agricultural Experiment Station of the Papua New Guinea Department of Agriculture and Stock). Both he and Murray maintained and further developed the botanical garden in Rabaul established by the Germans, endowing it with a growing reputation as a beauty spot (Michener 1951). From 1934 a small herbarium was built up under the agricultural botanist R. E. P. Dwyer (Frodin 1985). Few trips, however, were made. Among these was one by G. S. Gee to collect material of the citrus relative, *Clymenia polyandra*, for the economic botanist and citrus specialist Walter T. Swingle in the United States (van Steenis-Kruseman 1950, p. 187). The Forestry Service collections were, though useful, likewise not extensive.

Some of the private contributions, by contrast, were outstanding. Leonard Brass, as well as the collector and prospector S. F. Kajewski, both supported by the Arnold Arboretum through White, worked extensively in the Solomon Islands (including, in Kajewski's case, Bougainville), reaching higher elevations not previously examined by botanists. Kajewski later contributed an account of his experiences (Kajewski 1946). The Australian missionary teacher J. H. L. 'Harry' Waterhouse was engaged by British government interests to collect in the Solomons (including Bougainville); later he worked near Rabaul while teacher at a Government school. Serious collecting in the upper Watut basin (Morobe Province) was initiated by the anthropologist Beatrice Blackwood in 1936. The Japa-

nese botanists Ryoza Kanehira and Sumihiko Hatusima collected briefly in various centres in 1937. But all these efforts were overshadowed by the zealous collecting from 1935 of Mary S. Clemens, mainly in the Huon Peninsula north of Lae but also elsewhere in present-day Morobe Province. Her over 12,000 numbers were collected on a subscription basis, in the first instance for the Berlin Botanical Museum and, after the outbreak of World War II in Europe, for the University of Michigan. She continued to collect right up until her forced evacuation in December 1941 from Lae, and was so active in Australia until about 1950 (Langdon 1981; Carter 1982; Conn, this volume).

The predominance of private expeditions, both in the Mandated Territory and in Papua, stands in strong contrast to the Dutch East Indies at this period. This low level of scientific concern for the vast New Guinea domains has, however, to be viewed as part of a larger picture. Australia lacked the institutions, as well as the interest (beyond economic) to mount effective research programmes in New Guinea. At Federal level, serious concern for the development of the sciences had begun only in 1916 (Alexander 1972, pp. 66–68). The Council for Scientific and Industrial Research [later the Commonwealth Scientific and Industrial Research Organisation (CSIRO)] came into being in 1926 but played no role in New Guinea until after World War II. Botanical departments in the universities were small, and the opportunities for research extremely limited. It was the time of the 'long trough' (Donaldson & Good in Denoon & Snowden 1981, p. 143). That Lane-Poole's report became something of lasting worth was due to the hard work and dedication of the leader and his collaborators.

From 1918, however, botany seemed to enjoy a better hearing in Papua. Earlier I noted that an informal agreement with Queensland had enabled the Government Botanist there to act in an honorary capacity for British New Guinea (and, later, Papua). Murray invited White to Port Moresby soon after the latter's appointment. White's six week long visit in July and August of 1918 marked the beginning of a long and fruitful association with Papuan botany, ending only with his death in 1950. Beside his own contributions, White was to promote exploration by others, using funds from a variety of sources. Among his most important moves was recommending a young assistant from Toowoomba, Leonard J. Brass, to Charles Sprague Sargent — then nearing the end of his long tenure as director of the Arnold Arboretum of Harvard University — as collector for a proposed Papuan expedition, its first in the region. As he had done almost throughout his career, Sargent was interested in learning about new trees and other woody plants and obtaining herbarium specimens.

Brass undertook the expedition for Sargent in 1925–1926, obtaining nearly 1,200 well-collected numbers. The woody plants were studied by White and others, giving White his third long contribution to the New Guinea flora (White 1929). Sargent's plans for a second expedition were suspended due to his death (Sutton 1970, p. 345); but the work of White and Brass apparently stimulated the garden-loving and cricket-playing minister/principal of the Congregational seminary in Papua, Richard Lister Turner, to collect from time to time. After contributing lots respectively in

1918 and 1925 (from Rigo) and 1930 (from Fife Bay) he settled and collected at Delena on Hall Sound. In 1928 came the New Guinea Sugar Expedition, supported by the U.S. Department of Agriculture and the first to use an airplane for scientific exploration in the Australian territories (Sinclair 1978). Its botanist was Jacob Jeswiet from the Dutch East Indies. Beside sugar strains, plant collections were made in the Sepik as well as the then Central and Western Divisions of Papua.

The several biological and botanical expeditions of the 1930s were all privately sponsored. Among corporate ventures, the most important surely are the Archbold expeditions. In 1933–1934 the American Museum of Natural History in New York, under the leadership of the mammalogist and oil millionaire Richard Archbold, mounted the first of its seven New Guinea expeditions, which worked from Hall Sound (near Yule Island) to Mt Albert Edward, utilizing a trail system built by the Roman Catholic Sacred Heart Mission. For this, Brass was engaged as botanist. Further expeditions followed in 1936–1937 (Western District of Papua), 1938–1939 (western New Guinea), 1953–1954 and 1956–1957 (Milne Bay District of Papua), and 1959 and 1964 (northeastern New Guinea), on all of which Brass participated except the last. The Archbold expeditions, organized as small teams, had comprehensive objectives and were designed to sample altitudinal transects, thus covering as many habitats as possible in a given area. Those of 1936–1937 and 1938–1939, like the Sugar Expedition before them, made extensive use of air transport (Sinclair 1978). The plants of the first three trips were, along with those of a number of individual collectors, ‘worked up’ under the direction of Elmer D. Merrill in the United States. The resulting papers, by several authors including Merrill and his associate Lily Perry, were published almost entirely in *Brittonia* and the *Journal of the Arnold Arboretum* under the general title *Botanical Results of the Archbold Expeditions*. Appearing from 1935 until 1954, they represent the work of the only serious American research programme to date on the Papuan flora. White and his associate Stanley Blake also contributed, the latter all the Cyperaceae.

Individual collectors included the Russian (and later Swiss) Paul Wirz, looking at wild rice in western Papua in 1930, the British naturalist Evelyn Lucy Cheesman, who collected plants along with many insects in 1933–1934, and the English traveller Arthur Hugh Batten Pooll in 1940. Of far greater importance, however, were the nearly 7,000 numbers collected by the New Zealander and former rubber planter in Malaya, Cedric Erroll Carr. Arriving in Papua at the end of 1934, he stayed a year and a half before his death from blackwater fever in Port Moresby in June 1936. Like those of Mrs Clemens, his very substantial collections have never been entirely worked over (van Royen 1980). As with Schlechter before him, he specialized in orchids but did not neglect other plants. He also left a diary covering much of his trip, which surely should be one of the more interesting sources for the Papua of the mid-1930s.

Some of these collections, especially those of Brass and a small portion of those of Carr, were indeed written up and published relatively quickly. But the col-

lections of the 1930s all became available at a time of a move by researchers away from individual collection reports and towards a more consolidated approach to documentation along the lines of the *Beiträge zur Flora von Papuasien*, which from the 1920s had become more truly regional in scope, or the *Botanical Results of the Archbold Expeditions*.

These broader approaches to treatments of families and genera, in effect a partial return to the monographic tradition of the mid-19th century, were doubtless influenced by Engler’s Berlin and especially its *opera magna* like the *Pflanzenfamilien* and *Pflanzenreich* (Lack 1987a, b). Given relatively close ties at this time between Germany and the Netherlands (Meyer 1977), and the influence of German models on Dutch intellectual life (Pyenson 1988), it is not surprising that a renewed interest in broader family and generic taxonomic treatments would develop among Dutch botanists. For Malesia the first such work was Hermann J. Lam’s 1919 dissertation on Verbenaceae. Later, collections from all of New Guinea came to be incorporated into the Buitenzorg-based series of revisions *Contributions à l’étude de la flore des Indes Néerlandaises*, begun in 1923 at the ‘s Lands Plantentuin in Buitenzorg under its then-director, Willem M. Docters van Leeuwen (de Wit 1949, p. cxli) and a forerunner of the current *Flora Malesiana*, and into similar work elsewhere.

This submonographic approach, while scientifically sound and, in good hands, capable of definitive work, did at times overlook or downgrade the importance of more locally-oriented floristic studies and their influence on local perceptions of taxonomic research (Ng 1988). Moreover, effective prosecution of larger-scale research has tended to favour bigger institutions with substantial herbarium resources (Lack 1987a, p. 259). As we shall see, for Malesia these were, save for Buitenzorg and, to a lesser extent, Singapore, all in Europe and North America. Of these latter the best-founded was the Rijksherbarium at Leiden in the Netherlands. No Australian herbarium would have the strength or even mandate to contribute in this way until well after World War II.

F. Western New Guinea, 1875–1942: the rising Dutch presence

Before discussing the post-World War II period, we should look back at the history of botany in the western half of New Guinea, now the Indonesian province of Irian Jaya, and the background to the rise of a sustained Dutch interest in the study of the Papuan flora.

The early ‘flurry’ of official Dutch activity subsided with the publication of *Reizen naar Nederlandsch Nieuw Guinea* by P. J. B. C. Robidé van der Aa (1879). Only a limited amount of botanical work was done by visitors in the 1880s and 1890s, mostly in the western peninsulas and islands. Otto Warburg, whom we have already mentioned, visited McCluer Gulf early in 1889 before proceeding (via Cooktown) to German New Guinea. The director of the ‘s Lands Plantentuin, Melchior Treub, stopped briefly in nearby Ati-ati Onin during a tour of the Moluccas in 1893. Finally, Anna Weber-van Bosse, a phycologist, collected algae at Ati-ati Onin and in the western islands such as Gêbé, Misoöl and Waigeo while on board the *Siboga*

during that ship's year-long marine-biological and oceanological survey of the Indies in 1899–1900; her *Liste des algues du Siboga* (1913–1929, published in the reports of the expedition) and related papers are basic for the study of marine algae in Papuasias.

The *Siboga* voyage, however, was symbolic of a renewed concern for an effective Dutch presence in their 'outer possessions' in the face of increasing foreign interest. This concern was translated into effective policy under Indies Governors-General Willem Rooseboom (1899–1904) and Joannes B. van Heutsz (1904–1909). In New Guinea, development of the territories east of the 141st parallel, a desire to exercise greater control of the growing trade in bird-of-paradise plumes, and complaints from British New Guinea about raids by the Marind-Anim or Tugeri people in the south were among the factors which prompted the dispatch of naval patrols in 1901–1902 and establishment of a government station at Merauke (Thompson 1980). Other stations followed as lowland penetration and control proceeded.

These developments were soon followed by systematic exploration of the interior, still scarcely known east of the Bomberai peninsula. The most sustained series of expeditions took place from 1903 to 1922 — the longest such programme ever mounted in New Guinea — and again from 1936 to 1940, both periods of strong economic growth in the Indies as well as heightened official interest in the 'last carriage' (Souter 1964, p. 148).

In the period 1903–1915 Dutch efforts, supported by the metropolitan *Maatschappij ter Bevordering van het Natuurkundig Onderzoek der Nederlandsche Koloniën* (Society for the Promotion of Scientific Research in the Netherlands Colonies, now the Treub Society; Jacobs 1984, pp. 150–152) and its Indies counterpart, the *Indisch Comité van Wetenschappelijk Onderzoek* (ICWO, or the Indies Committee for Scientific Research) as well as the government and other bodies, at first focussed on the Merauke area and lower river systems of the south and the Mamberamo and Humboldt Bay areas in the north. From 1907 to 1915 Dutch military units undertook general exploration of much of the rest of the lowlands, joined with the Germans in a survey of their common border, and made initial forays into the central cordillera as well as the Arfak Mountains. During this period the scientific organizations concentrated on three expeditions to the Orange (Jayawijaya) Range and one of its 'snow mountains' (now without snow!), Mt Wilhelm (Pik Trikora). This peak, the highest in New Guinea save for Mt Carstensz (Pik Jaya) in the more westerly, present-day Sudirman Range, was finally ascended on the last of these, the Herderschee expedition, in February 1913. Botanically, the expedition was noteworthy in two ways: August Pulle, of Utrecht University, became the first Dutch professional botanist to participate on a New Guinea expedition; and he and Medical Officer Gerard Versteeg made the first significant collection of an alpine flora in western New Guinea (van Royen 1980).

Dutch activities were in this period augmented by several expeditions from other countries. The most important botanically were the second British expedition to Mt Carstensz in 1912–1913, on which Cecil Boden Kloss, then of Malaya, acted as naturalist; the

German-Polish naturalist Max Moszkowski's exploration of the Mamberamo Basin during his unsuccessful 1910 attempt on the 'snow mountains' from the north; and the Angi Lakes (Arfak Mountains) expedition of the intrepid Lilian S. Gibbs in 1913–1914.

The First World War interrupted exploration in Dutch New Guinea as in the rest of Papuasias, but resumed sooner than in the non-Dutch territories. The attention of the ICWO and other sponsors now shifted to the northern side of the central mountains. In 1920–1922, during a brief period of optimism in which for a time western New Guinea enjoyed separate residency status (Souter 1964, p. 148), two successive expeditions penetrated these from the Mcervlakte, the latter crossing the central highlands to Mt Wilhelm. One of Pulle's students, Herman J. Lam, then at Buitenzorg, acted as botanist on the first of these. A fine sketch of the flora as seen by Lam in 1920 appears in that author's *Fragmenta Papuana* (Lam 1927–1929, 1945). Among his accomplishments was the ascent of Mt Doorman, at 3,580 m one of the highest peaks in the northern part of the central ranges and one with an unusual flora. Lam produced a survey of its 'alpine' plants in the 1920s but, partly due to changing approaches already mentioned, its full treatment had to await publication of a general alpine flora more than fifty years later (van Royen 1979–1983).

In 1922–1923, due to a rapidly deteriorating economic situation in the Indies, the Dutch presence in New Guinea was reduced and, with one exception, all official exploration stopped until the 1930s. The only significant contributions were to be from a few foreign expeditions and by the 1926 Netherlands-American (Stirling) Expedition, sponsored by the ICWO and the Smithsonian Institution, which continued the work of the 1920–1922 expeditions but broke new ground through its use of air transport (Sinclair 1978, pp. 14–17). On this expedition Doeters van Leeuwen participated as botanist, making substantial collections.

The botanical results of this first exploration phase were, beginning in 1908, mainly published in *Nova Guinea*. This, a stately quarto series founded to receive expedition contributions in all areas, was issued at Leiden and supported by the Indies Committee, the Treub Society and the Dutch Colonial Ministry. Solid but not spectacular, they consisted largely of lavishly illustrated contributions on individual families by many botanists (among them several orchid papers by Joannes Jacobus Smith at Buitenzorg) but included some syntheses (e.g. the Sapotaceae, by H. J. Lam, published in 1931). From 1912, Dutch collections were also incorporated into the *Beiträge zur Flora von Papuasien* and from 1923 they likewise appeared in the Buitenzorg *Contributions*.

Some results of non-Dutch activities were also noteworthy. The major paper on Boden Kloss's collections, the already-mentioned *Report on the botany of the Wollaston expedition to Dutch New Guinea, 1912–13* (Ridley 1916), furnished the largest coverage of 'alpine' species since that of von Mueller 27 years before. Subsequent work has greatly enhanced but not substantially altered the picture of that flora presented in these two papers (van Royen 1980, p. 259). Gibbs began the serious study of vegetation ecology in montane New Guinea with her *Dutch North-west New Guinea* (Gibbs 1917).

In the 1930s, new pressures began to be felt in the Indies as the development of the Pacific Rim continued and Japan began to appear as a 'Great Power'. As a contemporary Dutch governor in the Moluccas, J. Tideman (in Klein 1935, p. 16) remarked in a report, 'to ignore this fact [the increase of economic activity in the Pacific] now when determining our policy in New Guinea would be to invite failure and worse.' The increasingly rapid development of the Australian territories, and the promise of the airplane, also could not be ignored. Moreover, there were signs that petroleum might be found. A *Nieuw-Guinea Comité* was formed, which supported renewed exploration efforts and promoted surveys and development of economic resources.

The 1936–1940 expeditions, along with surveys by the Indies Forest Service and other parties including those led by Zeno Salverda and Erik Lundquist, were to be productive for botany, if not more so, than the 1907–1913 period, yielding a second great flow of collections. The most important undertaking surely was the Indies-American Expedition of 1938–1939, which was led by Archbold who had, as we have seen, already made two visits to Papua. During its 11 months of operation his botanist Brass, along with his Dutch colleagues Ebertus Meijer-Drees and Christiaan Versteegh, collected some 6,000 numbers. Its most important discoveries were the Grand Valley of the Baliem and its 60,000 inhabitants, the last full species of bower bird, and the existence of *Nothofagus* forests. Brass described the latter in his botanical report (Brass 1941, pp. 336–7). Many more studies of Papuan *Nothofagus* would follow after World War II and lead as well to new floristic analyses (Good 1960; van Balgooy 1976).

The botanical collections of the 1935–1941 period initially found their way into *Nova Guinea*, the last parts of the Berlin *Beiträge* and the Buitenzorg *Contributions*, and especially the *Botanical Results of the Archbold Expeditions*. They would continue to be a rich resource for floristic, taxonomic and other studies after the Second World War. One collection, however, was published separately: that of Ryozi Kanehira and Sumihiko Hatusima made in 1940 on their second New Guinea expedition (their first having been a brief visit to the Mandated Territory in 1937). This appeared serially in the Botanical Magazine (Tokyo) in the early 1940s (Kanehira et al. 1941–1943) but unfortunately was not completed. It proved to be the last collection so published, and with its considerable percentage of purported novelties subsequently shown to be synonyms nicely illustrates that the time truly had arrived for the synthetic approach being advocated, as we have seen, at Buitenzorg and elsewhere.

The *Beiträge* and Diels' paper of 1921, already referred to, were the first 20th-century contributions seriously to attempt syntheses of taxonomic and geographic data for Papuasias. But, increasingly, the study of the New Guinea flora was becoming integrated into work covering the whole of Malesia. The establishment of the *Contributions* had reflected this trend (cf. de Wit 1949; Jacobs 1984, pp. 30–31), as did the monographic work of Lam and other Pullé students like Dirk van Slooten, Benedict H. Danser and Cornelius G. G. J. van Steenis. All these men were members of the Buitenzorg Herbarium staff which, before

1933 and Lam's move to the directorship of the Rijksherbarium at Leiden, was, as already for several decades, the sole significant research group for the Indies flora. In plant geography further stimuli were provided by the publications of Merrill on the relationships of the flora of Papuasias with the Philippines, and van Steenis (1934–1936) on the Malesian mountain flora. The latter included a synopsis of plant genera centering at over 1,000 m in altitude.

In the mid-1930s Lam took a major step forward in the study of the New Guinea flora. Building on the foundations laid by Beccari, Mueller, Warburg, Lane-Poole, Lauterbach and others, he (Lam 1934, 1935) supplied vegetation maps of the whole of New Guinea and nearby islands — the first of their kind — and suggested in his reviews that botanical work could be furthered as much by consolidation of what materials already existed as by new collections and observations. He also suggested that botanical and geological evidence should be dealt with together, and that alternative theories of continental masses — permanency vs. drift — be considered fairly. References to all family treatments in the *Beiträge* and *Nova Guinea* as well as other significant works were given.

In the report I have already mentioned, Brass (1941) also supplied a new review of the vegetation, incorporating more recent findings, and proposed a modification of the zonation schemes of both van Steenis and Lane-Poole. It was now becoming recognized, as not so before 1900, that the montane flora of New Guinea was very rich and, moreover, that a goodly part of the island's endemism was secondary and geologically more recent than was the case in Borneo which Lam (1934) had used for comparison. More penetrating analyses of the flora and its relationships with neighbouring areas, as well as further vegetation zonation schemes (or rejections thereof), would follow after World War II.

By 1942 the density of plant collecting in western New Guinea, while still relatively low by comparison with Java or Malaya, had reached a level between those of the former German and British territories in New Guinea (van Steenis-Kruseman 1950, p. cx). The Dutch, and to a lesser extent Merrill's group in the United States, had, however, assumed leadership in the study of the taxonomy, floristics and phytogeography of Papuasias, with the former gaining the dominant position after 1950.

The Dutch leadership, which effectively continues, is, I believe, due to several interrelated factors. Firstly, there was their historical presence in the Indies. The Germans, even though their contribution to Papuan botanical knowledge was substantial, were there for less than one-tenth that time; and American, Australian and British undertakings largely revolved around the work of interested individuals and/or particular needs. Secondly, from the late 19th century the Dutch were building up in Java the institutions which came to enjoy a high reputation in the pure and applied sciences (cf. Pyenson 1988). Including the '*Lands Plantentuin*', much enlarged under Treub, they undoubtedly were a significant factor in the success of the *Siboga* expedition and later on surely contributed greatly to the relative speed with which the natural sciences, including botany, were advanced in western New Guinea as well as elsewhere in the East Indies.

Thirdly, there were those at Buitenzorg and elsewhere who looked ahead to a comprehensive Indies flora. This was most strongly advocated by van Steenis, who had joined the 's *Lands Plantentuin* staff in 1927, and his colleague Danser. The phytogeographically rather than politically delimited *Flora Malesiana* project — the inclusion of the non-Dutch territories (save for the Solomon Islands) being decisive for the future integration of most knowledge of the Papuanian flora — finally came into being in the late 1930s and, as we have noted, succeeded the *Contributions* (which, though good in themselves, were thought to be too much a sideline). Finally, personalities: in addition to the interest of Pulle, appointed professor at Utrecht from 1914, two successive directors of the Rijksherbarium in Leiden, Lam (from 1933 to 1962) and van Steenis (from 1962 to 1972) made New Guinea (and Malesian) research a priority. Lam obtained a working agreement with Buitenzorg, which was extended after the war by formation of the *Stichting Flora Malesiana* (Flora Malesiana Foundation). Interested support also came from Lourens G. M. Baas Beeking, professor of general botany at Leiden and director of the 's *Lands Plantentuin* from 1938 to 1940 and 1945 to 1948.

The Dutch were fortunate in having two institutions which could serve as effective centres for *Flora Malesiana*: one metropolitan, one in Malesia. The large British institutions (and their satellites such as the Botanic Garden at Sibpur near Calcutta) dealt with the Malesian region as only one of numerous responsibilities. (Kew would, after World War II, become a significant secondary centre for the *Flora* project.) Among institutions elsewhere, those in Germany were facing changing circumstances (Lack 1987b; Timler & Zepernick 1987). In the United States only a few were seriously concerned with tropical systematics, these being largely oriented toward the Americas (save for the work of Merrill and his associates at New York and Harvard). As for Australia, the herbaria were, as we have seen, too poorly supported to undertake detailed taxonomic work on any but small (though important) parts of their own large flora. The *Flora Malesiana* project was thus, in the words of one of its early associates, Hendrik C. D. de Wit, well placed to 'contribute decisively towards a co-ordinated knowledge of the New Guinean plant world' (de Wit 1949, p. cxlix).

II. Institutions

A. World War II: the awakening

The Japanese invasion and occupation of Rabaul in January 1942 marks in every sense the start of the modern era in New Guinea and the Solomon Islands. The ensuing combat and associated activities engulfed nearly the whole of Papuasias, opening up the land and exposing most of its people to new sights, sounds, ways of life and ideas. The speed of the Japanese advance, the Battle of the Coral Sea, the war in the Solomons, the Kokoda campaign and Milne Bay drew world attention. Hundreds of thousands of combatants and others of many nationalities and professions brought a lasting new interest in the region.

Among the demands of any war are a knowledge of terrain and cover, field survival and — to the future benefit of botany in Papuasias — timber. Activities by

Japanese scientists and others doubtless contributed to the success of their invasion, but to date we know relatively little of work in the field or their botanical information system. It is recorded, however, that Peekel in New Ireland owed his survival under the occupation to his reputation as a botanist (Sleumer in Peekel 1985, p. 3). (That he preserved his MS. flora, which finally appeared 40 years after the end of the war, must be regarded as miraculous.) American and Australian field intelligence research was organized at Melbourne in an Allied Geographical Section (AGS). Among its many publications was *Vegetation study of Eastern New Guinea* (Allied Geographical Section 1943), which in its use of extensive air photo coverage broke new ground: 'very little work had been done up to the commencement of the war in the use of air photos in tropical forests . . . the mixed rain forest was an almost untouched field' (Womersley & McAdam, 1957, pp. 30–31). General surveys of vegetation and plant life were also prepared for geographical handbooks produced both by the AGS and the British Naval Intelligence Division. In the United States, E. D. Merrill produced a field survival manual, *Emergency food plants and poisonous plants of the islands of the Pacific*, and J. Hugo Kraemer a timber manual, *Native woods for construction purposes in the Western Pacific Region*. Both were revised and republished after the war, respectively as *Plant life of the Pacific World* (Merrill 1945) and *Trees of the Western Pacific Region* (Kraemer 1951). Bibliographies, covering the whole of the Pacific theatre of war, were also produced, namely *An annotated bibliography of the Southwest Pacific and adjacent areas* (Allied Geographical Section, 4 vols.) and *Toa kyo-ei-ken sigen-kagaku bunken mokuroku* (Japanese Department of Education, 6 vols.); both include botanical coverage.

The war also brought progress in forest botany. The appearance of *Native woods* in 1943, though restricted to armed forces use until 1945, was, as its author noted in the 1951 edition, the first dendrological work for the Western Pacific to appear in the United States. He could have added Australia: while Lane-Poole's 1925 report was a step forward, it was not a manual nor was it systematically illustrated. As we have seen, forestry in the Australian territories had been on a small scale and surveys few. Indeed, it is likely that without World War II, the Dutch foresters in western New Guinea would soon have been well ahead in Papuanian forest botany (and in fact the Boswezen Nederlands Nieuw Guinea made considerable progress in the lowland forests after the war). Allied troops — and especially the CB's (Scabees) — in the Solomons, at Milne Bay, in Buna and from Salamaua to Madang must have relied on local knowledge or on American sources such as Kraemer's work for timber identification and use. They were surely also aided by Carl De Zeeuw, a former student at the State College of Forestry in Syracuse, New York, as well as others not yet recorded. The well-known Australian contribution to New Guinea forest botany belongs only to the later period of the war, when the main military objectives had shifted northward (Ryan 1972); we shall return to this later.

Many individual servicemen collected, making use of what must have been a precious opportunity. The Australians H. J. Root and N. A. Wakefield collected on their own, the former mainly in the Port Moresby

area. With respect to American servicemen, E. H. Walker (1945, 1946) has given overall reviews of their work, in which they were encouraged by a naval education officer, David F. Grether. However, without a formal mechanism for processing and publication collections and observations soon became widely scattered, as Walker himself noted. Some from Papuaia were only partially or not at all studied. Among the most useful were Levi T. Bureham's grass collections, later published (Bureham 1948), and especially the combined work, continued until 1946, of Grether and Warren H. ('Herb') Wagner on pteridophytes in the Admiralty Islands (Wagner & Grether 1948). Mainland collectors included John R. Reeder, who would also publish on grasses (Reeder 1948); later he specialized in that family.

B. The 'New Guinea Forces' (N.G.F.) collections

Besides forcing the defence of New Guinea and Australia, the war laid bare the limitations of earlier Australian policy towards the territories and the 'perfunctory operation' of responsible authorities, especially the then-Department of External Territories (Ryan 1972). Into this policy vacuum came what Ryan has termed a 'remarkable army unit', the Directorate of Research and Civil Affairs (DORCA), organized in 1942. With an expert body of members (which included the first postwar Administrator of the combined Territories, Col. J. Keith Murray) and much specialist advice, they recommended that over a broad range of social, cultural and political, as well as economic, activities a different, essentially more activist approach towards development was needed. Capital expenditure on a much larger scale would be called for, though always, however, with the hope of some greater economic return.

Among the fields singled out by DORCA was forestry. It should therefore not come as a surprise to suggest that in DORCA's planning lies the origins of the T.P.N.G. Department of Forests. But the work of DORCA, and its activist point of view, also influenced government decisions on the conduct of the war in New Guinea (Ryan 1972). I believe that as part of this admittedly controversial policy, which in any case would have made new demands for timber, there came in March 1944 the organization of two Forest Survey Companies as part of the Australian Army Engineers. These were placed under the command of James B. ('Jim') McAdam, who was one of the two foresters appointed to the Mandated Territory in 1938. Aware that the forest trees were still poorly known, and with an eye to the future, McAdam arranged for collections of herbarium material and timber and wood samples to be made.

The work was initiated at Lae by Cyril White, along with H. E. Dadswell from CSIRO's Forest Products Division in Melbourne, and carried forward by several interested forester-servicemen in a large number of areas under the general supervision of Lindsay Smith from the Queensland Herbarium (Womersley 1953). White and Smith gave botanical and dendrological lectures which were later revised by E. E. 'Ted' Henty and published in 1961. The collections, numbered in a series called 'New Guinea Forces' (N.G.F.), were sent to Brisbane for study but, a set of these, left in Lae at the close of the war, would form the nucleus of the

botanical service envisioned by McAdam. White returned to the region in 1945 to assist with similar work in the Solomon Islands (Walker 1948; White 1950) and, after the war, gave much assistance to what eventually became the Division of Botany in the Papua and New Guinea Department of Forests before his untimely death in 1950.

C. Postwar development in P.N.G. and the Division of Botany

In 1945 a provisional Papua-New Guinea administration came into being under the leadership of J. K. Murray. In the following year, doubtless after some debate (Michener 1951), Australia was awarded trusteeship over the former Mandated Territory of New Guinea. The activism of DORCA and the 1944-1945 Australian campaign had made their point, and the new arrangements ensured that Papua, in 1942 even less developed than was the Mandated Territory, would benefit. More permanent arrangements, including establishment of a Territories public service, came into effect in 1949 with passage of the Papua and New Guinea Act.

In an effort to summarize current knowledge and stimulate development, the Australian Commonwealth soon after produced *The resources of the Territory of Papua and New Guinea*, which included an atlas (Australia, Department of Regional Development 1951). Expansion of the government departments most concerned with the economy, including Agriculture, Stock and Fisheries, Forests, and Lands, Surveys and Mines, provided some scope for the growth of government science activity, and in 1949 interested scientists and others formed the Papua and New Guinea Scientific Society (Salter-Duke 1984).

The next logical step would have been the establishment of one or more government scientific centres. Such centres already existed in many dependent territories, or would be developed in the future. Australia itself, in CSIRO, had a model. But relative proximity to the metropolitan country, the evident lack of a science policy, the strength of public service traditions (cf. Sir David Rivett in Oliphant 1951, p. 162), the growth of bureaucratic rivalries (Frodin 1988; P. F. Stevens, pers. comm.), regressive tendencies (Hasluek 1976) and a seeming absence of vision prevented formation of such a centre — if, indeed, the idea was ever contemplated. Accordingly, until establishment of the universities in the 1960s the sciences in New Guinea, including botany, were almost entirely the province of government departments.

Given these factors, what was accomplished in the sciences in the remaining years of Australian administration depended, in my opinion, very much on individuals. With respect to botany, Henty (unpubl.) believed that, in addition to the general commitment to greater development expenditure, the appointment of McAdam as acting secretary and later as the first Director of Forests, was a prime factor in the creation of a distinct botanical service linked with a botanical garden.

The office of the Forest Botanist was accordingly established at Lae in 1946. (It became the Division of Botany in 1954 and in 1984 was combined with other forest research activities as the Division of Botany and Forest Management Research. It is now, or will be,

part of a new Forest Research Institute.¹⁾ John Womersley (1920–1985) was appointed in August 1946 and began work in Lae early in 1947. He was the sole professional employee until 1953, when a second post, for a botanist/ecologist, was created and Alex Floyd appointed. The first Papua New Guineans who would become well known in their own right joined around 1955: Nima Kokori and Michael Galore. Shortly afterwards, Floyd resigned and in mid-1957 was succeeded by Kevin J. White, a Queensland forester who, however, moved two years later into an administrative career within the Department (ultimately becoming, until his retirement in 1977, First Assistant Director for Research and Training which included overall responsibility for the Division). E. E. ('Ted') Henty also joined the Division in 1957, and would remain for 27 years until his retirement at the end of 1984.

In the 1960s, more positions, in all grades, were created as additional funds became available. By the end of the decade the establishment included, besides Womersley, six professional staff — 4–5 in the Herbarium and 1–2 in the Gardens, the latter including a curatorship (first instituted in 1963). The larger staff made possible not only a more diversified programme of work (and publication) but also more opportunities for Papua New Guineans.

Among the latter were several field assistants, the names of some of whom would become well known: Yakas Lelean, who joined in 1964; Paul Katik, who joined in 1966, and Artis Vinas, on the staff from 1971–1979. Katik in particular developed a superb knowledge of plants, much as had the late Indonesian *mantri* at Bogor, Nedi. They sometimes collected on their own but more frequently were on parties headed by professional staff, including (in 1965–1966) the writer.

Non-national staff on average stayed only a few years. Among longer incumbents, besides Womersley and Henty, were Mark Coode (1966–1972) and James R. ('Jim') Croft (1973–1987). But perhaps the most colourful — and controversial — was 'Plaau Missis', Mrs Andree Millar (1916–). Appointed in 1956 as Gardens Assistant, she was Acting Curator for more than two years before her resignation early in 1971 and move to Port Moresby. Through her work in general gardening, shows, and especially orchids, she became better known among the Territory public than any other botanist. Indeed, one historian has claimed that 'she established a more productive relationship with the environment than almost any other Australian' (Nelson 1982, p. 106). Her book on orchids (Millar 1978), if somewhat flawed, remains the best lay introduction to Papuasians' rich orchid life. But, for a decade and a half, life in the Division revolved around the rivalry between her and Womersley.

The Divisional staff after 1960 also included illustrators as its publications programme accelerated. The first, Damaris Pierce, was appointed in 1964. Later, at different times, Terry Nolan, Fayc Owner, Taikika Iwagu and Semeri Hitignue — the last two Papua New Guineans — were staff illustrators. Between them they have produced nearly 2,000 plant drawings, many still unpublished.

The goals of the Division when organized as such were: 1) maintenance of a herbarium and botanic garden; 2) study of the vegetation of New Guinea, especially the eastern section; 3) provision of an identification service and advice; and 4) planting of the garden with native and exotic ornamental and useful plants and trees, and the supply of [nursery] stock to the public (Henty, unpubl.) In 1957 the Division assumed effective responsibility for government botanical services as well as collections in all plant groups save fungi (all of which were transferred to the Department of Agriculture, Stock and Fisheries in Port Moresby). Perhaps fulfilling McAdam's vision, it thus became one of the many 'gardens for science and pleasure' (Hepper 1982) which, inspired by Kew, had been established almost throughout the British dominions and colonies, including Australia (cf. Broekway 1979).

The early years were devoted to rescue of the abandoned set of duplicates — some 2,000 numbers — of the wartime Forces collections as a basis for establishment of a workable herbarium, and to building the botanical garden. By 1949 the latter would have 57 hectares (with the added responsibility of the adjacent war cemetery). An old residence on the property, close to the present Herbarium which replaced it in 1965, was used as a headquarters with two nearby buildings serving for garden operations.

The N.G.F. series was continued by Womersley and his staff as the official institutional series. Beginning at about 2,600, numbers reached the 12,000s by 1960 but then began to accumulate more rapidly as staff and activities further increased. In 1965–1966 the range was 25,000–32,000; and around 1970, when numbers reached 50,000, the designation was changed to LAE but without breaking the numeration. At present the 80,000s have been reached but growth since 1975, and even more so in the 1980s, has slowed (cf. Pranec & Campbell 1989, p. 525).

In the first decade and a half collections were made by a number of foresters in the Department as well as by the botanical staff, and a good basic record of big forest trees was built up. By the early 1960s, however, there was a shift to the flora as a whole, with most contributions to the series coming from the Division of Botany and the Forestry School (later College) at Bulolo. The latter made many collections of big trees as well as of the flora in the upper Watut basin south of Lae and elsewhere. The Herbarium has also acquired many specimens from other government officers and private residents as well as from the large number of visiting expeditions and individual scientists, in conformity with customs regulations in force from 1951. It also has managed to obtain, through exchange, duplicates of some of the pre-World War II collections. Sets of the BW-series from western New Guinea, collected between 1955 and 1962, as well as collections from other Dutch expeditions in that territory are also available, along with a set each of the BSIP and RSS numbers from the Solomon Islands. A small library, as well as collections of photographs and drawings, were also built up.

Publications appeared only slowly in the first decades after the Division was established. The first major work, still cited, was *The forests and forest conditions in the Territories of Papua and New Guinea* by

¹ Opened on 8 April 1989

Womersley and McAdam (1957), prepared for a British Commonwealth Forestry Conference held in that year in Australia. In 1961 the White botanical lectures were published as an aid to students at the new Forestry School at Bulolo and two years later there appeared *The vegetation of the island of New Guinea* by Pieter van Royen (van Royen 1963), originally prepared in 1961 for the Tenth Pacific Science Congress in Honolulu.

Pressures began to mount, however, for more readily useable manuals and other floristic works, and from 1964 publications began appearing more rapidly. We mention here *Manual of the forest trees of Papua and New Guinea* (van Royen *et al.* 1964–1969), in nine parts, with one revised, but never completed and now partly outdated; an irregular series of *Botany Bulletins* (1969–); and, finally, the ambitious *Handbooks of the Flora of Papua New Guinea* (Womersley *et al.* 1978–), planning for which began in 1970 and of which to date two volumes have been published by Melbourne University Press. Others will be discussed below.

Staff would also contribute to other works, and would prepare separate research papers; but with relatively few exceptions systematic studies in the larger seed plant families, and still more so the cryptogams and non-pathogenic fungi, have continued to be prosecuted by botanists in more developed countries. Even more than in Australia itself, systematic botanists in New Guinea, or in Australia and working on the Papuan flora, have been dependent, and are likely long to remain so, on widely scattered, distant outside herbaria. The destruction of most material from former German New Guinea (save for the pteridophytes) in Berlin in 1943 will remain a great handicap. Fortunately, the herbarium in Lae is, at more than 250,000 specimens mostly from Papuasia, of a size suitable for research; those in the Indonesian province of Irian Jaya and in the Solomon Islands, were, like other herbaria in Papua New Guinea, organized as, and have remained, comparatively small reference collections.

Yet while some revisionary work was done at Lae, particularly in the late 1960s and early 1970s, and from time to time (as qualified personnel were available) studies of vegetation were made, it was the Procrustean tasks of collecting, identifying, specimen curation, the making of illustrations, correspondence, organisation of field work, hosting of visitors, and related duties which formed a large part of daily activities. Development of the Garden also absorbed a particularly large share of attention up to the 1960s, and remained important as that part of the Division's activities most visible to the public, especially with its central location in the city of Lae.

The Division has accounted for the largest single share of botanical exploration in Papuasia since 1945. I think it fair to credit John Womersley for much of this achievement, whatever criticism may also be merited — including the development of a certain 'distance' from other government activities. However, the last time I ever saw him (in 1984), he said to me, 'Jim McAdam's death [in 1959] was a great loss.' In spite of the tone of 'official' accounts, such as that by Angus (1972), the Forest Service was afterwards not the same, and perhaps could not have remained so: government policy changes, especially those resulting

from the 1962 United Nations Visiting Mission (Souter 1964) and the World Bank study, *The Economic Development of the Territory of Papua and New Guinea* (International Bank for Reconstruction and Development 1965) led, among other things, to an emphasis on forest development and production. The changed atmosphere is well illustrated by the promotional booklet *New Horizons* (Department of Forests 1973), as well as in the planning for a forestry degree course (Howie-Willis 1980, pp. 166–176). Botanical research moreover failed as such to become effectively incorporated into national goals, in part due to the already-mentioned 'distance' of the Division of Botany (Stevens 1989, p. 131). Tidy public service minds began to see the Division as an anomaly, with consequences to which we shall return.

It is in the face of such changes, which especially from the 1960s were quite rapid, that the already-noted lack of interest in some form of integration of government research resources becomes apparent (Frodin 1988). Most scientific work, including the development of natural science collections, had more or less followed departmental priorities, and physically was widely scattered. In particular there was no one body which would be able to carry out integrated natural science research in the manner of CSIRO's LRRS. Had there been, perhaps some of the problems surrounding the JANT integrated timber development in the Gogol Basin near Madang (Webb 1977) would have been lessened. The lack of suitable statutory research institutes also exacerbated the problem of long-term support of living resources, such as the Papua New Guinea Biological Foundation banana collection (King & Bull 1984). The present National Museum and Art Gallery, re-established in 1954 (Frodin 1988), has been primarily concerned with cultural history. What long-term collaborative research and service arrangements with counterparts in Australia (or elsewhere) existed was ad hoc, often based on personal relationships. Consultancy was usually on a case-by-case basis.

D. Other botanical centres in Papuasia

Internal development in Papua New Guinea, especially in education and privately sponsored research, but also in local government and politics, was also creating new needs and desires, some not foreseen in earlier years. Moves for additional botanical centres emerged, partly in reaction to the Division of Botany, but mainly to support specialized areas of applied research and, later, higher education and basic biological and ecological studies. More parks and botanical gardens were established. Interest in, and concern for, the New Guinea flora was becoming — as Womersley would not easily admit — too large and diversified for monopoly by a single organization.

The first two of these additional centres were the Plant Pathology Branch of the Department of Agriculture, Stock and Fisheries (now the Department of Agriculture and Livestock) at Port Moresby, and the Forest Research Station at Bulolo. In Port Moresby, a considerable herbarium of thallophytes, mainly pathogenic microfungi, was built up from about 1955 under the direction of Dorothy Shaw (to which, in 1957, were added all fungal collections from Lae), and a compendium of pathogens published (Shaw 1963).

The Bulolo centre was established shortly afterwards in connection with reafforestation activities in the Watut Valley and two collections came into being. A herbarium of forest trees was started by a forest officer and dendrologist, the Czech emigre Jacoboslav J. ('Joe') Havel, which went around 1962 to the nearby Forestry School (later College) and has been added to, though on a relatively small scale, since. As at Lae, the professional staff had field assistants who accompanied them, often as part of class field trips, or worked on their own. The best-known is Aubeta Kairo, who began work at the School in the early 1960s and was still active by the mid-1980s. The second collection at Bulolo, which remained at the Research Station, comprises fungi associated with forests and wood, and is strong on polypores. It has no counterpart elsewhere in the country.

The College staff have rather actively contributed to the literature, particularly in student texts and manuals — arguably more productively so than at Lae. Havel, for a time Principal (until 1965, when he returned to Western Australia), produced a dendrological handbook to major timber species, *Forest Botany* (Havel 1970–1975), which incorporated a fine essay, 'Teaching tropical forest botany' [originally published in *Unasylva* 19 (1965)]. This work was later revised and expanded by the New Zealander Robert J. Johns as *Common forest trees of Papua New Guinea* (Johns 1976–1978). Johns also initiated another series, *A student's guide to the monocotyledons of Papua New Guinea* (Johns 1981), of which at this writing three additional parts have appeared (Johns & Hay 1984), including one (by Lord Alastair Hay) on the palms — the first modern survey for New Guinea of this important family — and another (by Neville H. S. Howcroft, of the Research Station) on orchids. Havel, Johns and other college staff teaching botany, ecology and dendrology also contributed technical papers. Barry Conn, a staff member in the mid-1970s after service at Lae, produced an introductory botany text (Conn 1979) which drew as far as possible from local sources. Howcroft wrote a number of semi-technical articles on orchids, mainly for the *Orchadian* in Australia.

At the universities, founded in 1965 at Port Moresby respectively as the University of Papua and New Guinea (UPNG) and the Institute of Higher Technical Education (the latter soon after moving to Lae and around 1975 becoming the University of Technology), herbaria were also established. At UPNG, collecting began in 1969 and the herbarium, when effectively established within the Department of Biology, became the only general herbarium in the national capital, providing services to the teaching staff, students, government and the public. It directed part of its attention to the interesting flora of the Port Moresby region, where a strongly seasonal climate prevails. In an attempt to increase knowledge of this flora work was initiated in the mid-1970s on a regional flora project. This was to be based on all known records — not an easy task, as the vast majority by then were widely scattered elsewhere, the area having one of the longest histories of collecting in New Guinea (Frodin 1981). A handbook to mangroves was also produced (Frodin *et al.* 1975; Frodin & Leach 1982), as well as a manual of aquatic macrophytes (Leach & Osborne 1985). Individual research projects were also pursued. After a

serious fire, the Herbarium was re-housed in a new university building complex, the Natural Sciences Resource Centre, in 1984 (Lambley & Frodin 1987).

A teaching herbarium was also established at the University of Technology when its Department of Forestry (established in 1975) took over full responsibility for the national undergraduate forestry degree course in 1980. Dubbed the Leonard J. Brass Memorial Herbarium, it has served as a base for botanical and ecological activities by Johns, who joined the University in 1979, and his associates: forest ecology (especially of dipterocarps; much work, however, remains unpublished), dynamics (the development for New Guinea of the idea of 'unstable' forests having been one of Johns's special interests), and the continued preparation of student manuals — a necessity in Papua New Guinea, where much literature is too technical.

Collections have also been made at biological research stations, notably the Wau Ecology Institute, and most recently the Christensen Research Institute, and by private individuals, including missionaries. Among the latter are the Rev. Norman Crutwell and Brother O. William Borrell. Borrell has prepared a flora of Kairiru, a high off-shore island near Wewak.

Elsewhere in Papua New Guinea locally-based botanical work was largely connected with a systematic forest survey. The already-mentioned *Boswezen Nederlands Nieuw Guinea* was started in Hollandia (now Jayapura) in 1950 and a herbarium established in 1952 (moved to Manokwari in 1958). Collections were made in a series labelled 'Boswezen', abbreviated to BW. These were largely from lower elevations and, to a greater degree than in Papua and New Guinea, comprised almost exclusively tree species (though towards the end of Dutch rule they became broader in scope). By October 1962 almost 15,000 numbers had been collected. In the Solomon Islands a forestry survey was mounted shortly after the war (Walker 1948; White 1950) but the resulting BSIP-collections were relatively few in number and not added to until survey work was revived on a larger scale in the early 1960s with funds from the Overseas Development Administration. As part of this effort collecting in the BSIP-series was resumed by Timothy Whitmore, as forest botanist, together with a number of local assistants and associates, and by 1970 had reached some 17,000 numbers. As in western New Guinea these were heavily oriented towards tree species, though perhaps less narrowly so. In 1965 a considerable boost came with the work of the Royal Society expedition, noted below. However, budget restrictions have since largely curtailed further collecting and for several years the herbarium in Honiara has been relatively inactive. A forest tree guide has been published (Whitmore 1966).

E. Metropolitan visitors

Local institutions, while making an impressive showing, were, however, not alone. Institutions and individuals from Australia and other countries also made large contributions, sometimes in areas of botany not well developed locally. I now consider these 'metropolitan' activities.

The most substantial Australian contributions came from Federal institutions, notably the former Land

Research and Regional Survey Division (LRRS) of CSIRO, the Australian National University, and, at a later date, the National Botanic Garden in Canberra. The LRRS was first into the field. This unit came into being after World War II when it was recognized politically that the potential of many parts of Australia, particularly in the north, was poorly known. Their speciality was an integrated geographical approach to land evaluation in selected areas, one which usually included plant collecting and vegetation survey and sometimes forest assessment. Field work in New Guinea began in 1953 and in the following sixteen years fourteen surveys were conducted, covering perhaps 40–50% of the land area of the two Territories. For eastern New Guinea, the surveys were novel in that they were systematic, and bore a partial resemblance to the work of some of the German expeditions. Several botanists and ecologists participated, including Ruurd D. Hoogland, who also created and built up a botanical section (now part of the Australian National Herbarium in CSIRO) to house the resulting collections. Chapters on the vegetation and forest resources were prepared for incorporation into the land reports, the first of which appeared in definitive form only in 1964 and the last in 1976. Many separate botanical and ecological papers appeared in a variety of journals, including (from 1973) *Contributions from the Herbarium Australiense* and its successor *Brunonia* (now *Australian Systematic Botany*), but no consolidated 'botanical results' were published.

At the end of the 1960s, with self-determination approaching sooner than had been envisioned fifteen or twenty years before, the New Guinea surveys were largely wound down and the Division given a five-year mandate to prepare consolidated reports. Three maps (including one for vegetation) and four monographs [including *New Guinea Vegetation*, edited by Kees Pajmans (Pajmans 1976)] have so far appeared. The value of the three contributions, respectively by Max van Balgooy of Leiden (on plant geography), Pajmans, and Jocelyn Powell (on ethnobotany) of Sydney, in the vegetation volume is attested by their frequent citation by other researchers. Cooperative work between the Papua New Guinea Government and LRRS's successor body, the Division of Water and Land Resources, was from 1980 revived with particular reference to subsistence agriculture (Potter 1984, p. 21), but the more limited scope of these studies has meant that much of the legacy built up over twenty years has not been effectively utilized or added to.

One important collection made under CSIRO auspices was written up in full. This was the phytochemical survey in 1961–1964 by Thomas Hartley from the United States, financed partly by a U.S. pharmaceutical company. Along with some 3,700 plant collections, samples were tested for active properties, both in New Guinea and in CSIRO laboratories in Melbourne. A check-list, including botanical names and activity codes, subsequently appeared (Hartley *et al.* 1973), a major addition to the more limited results of Leonard Webb's 1951 survey (Webb 1955). After Hartley's departure from New Guinea, funds continued to be made available over a number of years for collection of larger samples of particular species as required by the sponsors. [As this is written sampling has been resumed as part of an international pro-

gramme sponsored by the National Cancer Institute in the United States.]

The Australian National University (ANU) formed its Research School of Pacific Studies in 1951. Its Department of Geography was later expanded to include biogeography and geomorphology and from around 1959 Donald Walker and his students and associates built up the largest Australian group in the field, achieving separate departmental status in 1970. They became the effective founders of modern vegetation science and Quaternary studies in New Guinea, moving away from mere tabulation and description as had been hitherto usual. Developments in the earth sciences had also renewed interest in biogeography. At the same time also there was a developing concern with ethnobiology. In New Guinea research fields initially focussed on montane and subalpine vegetation and the record of its past as preserved in lakes and swamps. Later, interest was expanded to include lower elevations. However, since the late 1970s field work has been greatly reduced, with Geoffrey S. Hope the only one continuing into the 1980s with study sites in the Wharton Range and in Irian Jaya.

Several theses were written and analytical and synthesis papers have appeared over the last 25 years, but much remains unpublished. As well as the work of Pajmans already referred to, mention should here be made of *Bridge and barrier* (Walker 1972),

The equatorial rain forest (Flenley 1979), which covers the whole tropics, the first volume of *The alpine flora of New Guinea* (van Royen 1980), and papers by Walker and Hope, Jim Smith, and others in *Biogeography and ecology of New Guinea* (Gressitt 1982), as well as a general survey of montane and subalpine forests (Grubb & Stevens 1985).

As with CSIRO, the work of ANU staff and students resulted in a substantial body of collections, which were deposited in the CSIRO LRRS herbarium. The ANU-series, however, also contains material from Australia and elsewhere. Other workers have cited some of these specimens in their descriptions of novelties, revisions and monographs.

I turn now to the work of other visitors to New Guinea, including that in continuation of programmes started before World War II. Since 1914, no major *general* expeditions had been mounted in eastern New Guinea, unless the 1921 economic 'exploring expedition' is counted. Although Behrmann (1924) had, properly, lamented the near-absence of new exploration and the reduction in scientific work in the former German territory, changing methods and fashions in research, increasing specialisation in the sciences, costs, the appearance of the airplane (and, later, the helicopter), easier access for individuals, a surge of new development in many areas after 1925, and the rise of local institutions, reduced or eliminated the need for the often overly massive general expedition. Biological exploration became separate, and geographical exploration would be more closely linked to administrative or, in the Mandated Territory, even commercial penetration (Firth 1982). In western New Guinea general expeditions continued for a longer time, but save for the already-mentioned Stirling Expedition in 1926 and, in some respects, the Star Mountains Expedition of 1959 — which figuratively eliminated 'the last white patch on the map'

(Brongersma & Venema 1962, p. 18) — they were not on the scale of the expeditions of the 1903–1922 period.

About the only large biological survey expeditions were those conducted by the Arehbold Expeditions foundation in New York, previously mentioned. After a trip to the Cape York Peninsula in 1948, there were four further New Guinea expeditions, in 1953, 1956, 1959 and 1964. Brass was botanist of the first three of these, and Hoogland on the last. As before the war, areas were systematically selected and sampled. The botanical collections — handled in all by four different institutions — were not, however, written up in the earlier manner, although botanical summaries continued to appear in the expedition reports.

As for American work on the Papuasian flora, with Merrill's retirement from the directorship of the Arnold Arboretum research interests at Harvard largely moved elsewhere, although Lily Perry, Thomas Hartley and Peter Stevens successively acted as curators for Papuasian botany until the 1970s and its *Journal* continued to carry contributions. Not again, however, has there been in the United States an active institutional centre comparable to those which have concentrated on different parts of Middle and South America since the 1880s. What long-term programmes of support for work in New Guinea currently exist are mainly in Europe and Japan.

Ship-borne expeditions became largely concerned with oceanology and marine biology. I shall mention two, however, which did considerable land work: the Danish 'Noona Dan' expedition of 1961–1962, which while in Papua New Guinea worked in some rarely visited areas (but whose collections contained few duplicates); and the British 'Operation Drake' in 1979, whose major interest was beta-adventure but which did some serious work in the forest canopy using walkways — rarely if ever attempted before in New Guinea. The latter's experiences are recounted by Mitchell (1986).

In contrast to such general expeditions the growth of infrastructure in New Guinea and the formation of the Division of Botany, as well as the trend towards greater specialization, promoted the mounting of more botanical expeditions. Operations would usually be carefully focussed (cf. Lam 1960, 1961), and liaison effected with local botanists. Dutch expeditions were the most numerous, extending from 1954 to 1975 and beyond, and sometimes prolonged (van Royen in 1954–1955 was nearly a year in the field). From 1963, reflecting the priorities of van Steenis (now director of the Rijksherbarium in Leiden) the high mountain flora received particular attention. All of them were wholly or partly sponsored through his institution, save one by van Royen in 1976 organized through the Bernice P. Bishop Museum in Honolulu — and which provided a partial basis for his *Alpine Flora of New Guinea* (van Royen 1979–1983). The mid-1960s saw the resumption of British expeditions, beginning with that in 1964–1965 by Clive Jermy and others which specialized in pteridophytes and other cryptogams, and followed by two from Kew, one in 1969 and one in 1975. In 1965 there took place the Royal Society Solomon Islands expedition (Corner *et al.* 1969). There were two student expeditions from Oxford in the 1980s. The longest was the nine-month study, in

1970–1971, by Peter Grubb and Peter Edwards, of the structure, composition, dynamics and functioning of a montane rain forest near Goroka. This resulted in several papers in the *Journal of Ecology* and, ultimately, a monograph (Grubb & Stevens 1985). From the late 1960s Japanese were again active, and have conducted five expeditions: four from the National Science Museum in Tokyo (1964–1975), and one, in 1985, from Osaka City University. Those from Tokyo paid particular attention to cryptogams and fungi, including those in the highlands (cf. Kobayasi 1971).

I cannot mention separately all the many individuals who have come to New Guinea to prosecute research projects and collecting. The diversification of botanical work and changing trends of scientific enquiry have greatly influenced what individuals do during their stay. There has been a marked rise in such visits, beginning in the 1960s. Researchers have represented a great many organisations, or come on their own. Their presence has introduced an element of complexity: while activities have been made more possible by greater ease of travel and improved infrastructure they also have introduced an element of local concern. A goodly part of the outsiders' work has been in the areas of vegetation science, ecology and prehistory, which has involved extended stays in study areas.

F. 1975 and beyond: changing scenes

Papua New Guinea gained internal self-government in 1973 and full independence within the Commonwealth of Nations in 1975. The Solomon Islands were granted independence from the United Kingdom in 1978. With these political developments came policy and other changes which, along with economic factors, have had a considerable impact on the development of the botanical sciences. The appearance of *Biogeography and ecology of New Guinea* (Gressitt 1982), which came at a time of major world recession as well as changes in the public perception of science, may reasonably be taken as marking the end of this account as well as of the post-war era.

John Womersley retired as Chief of the Division of Botany in 1975 after 29 years and, not being offered re-employment, returned to Australia where he entered into other pursuits until his death in 1985. Expatriate staff at the Lae Herbarium (which in 1974 became the Papua New Guinea National Herbarium), still numbering 11 in the early 1970s, quickly fell and by the early 1980s only three remained. Productivity also declined, and maintenance of the collections became an increasing problem. In 1983 there was a budgetary crisis, resolved only through local and overseas protest. While the immediate causes were planning and budgeting errors, the incident suggests that not only was the past 'isolation' on the part of the Division responsible but also that botany had yet to win an effective place in national life (cf. Stevens 1989).

Broader issues, though, also acquire significance. In many developing countries, Papua New Guinea among them, basic research and documentation, in spite of apparent support for the sciences through education, has not fared well (Yeboah-Amankwah 1984, p. 5; Šlaus 1987, pp. 16–17). Research and development activity in the new country moreover was, through inheritance, not well organized and generally

lacked an effective institutional-cum-political base. It is thus to be regretted that at a major meeting, the 1984 Waigani Seminar 'The role of science and technology in the development of Papua New Guinea' (Morton 1984), these issues were not squarely addressed although many areas, including teaching, were examined in some depth.

Relatively few Papua New Guineans have entered botany, partly because of lack of encouragement but also because opportunities in other areas have been more attractive. Only Osia Gidcon and Simon Saulci (at least in systematics and vegetation science) have so far published in international journals. Many others have been involved, though largely in support roles. Papua New Guinean scientists generally are too few (Pernetta & Hill 1984), a situation I believe has been aggravated also by the present institutional science structure, in large part inherited from before independence. Without a good career structure for research and a sense of security further professional development will be hampered. The establishment of the Forest Research Institute at Lae represents a step in the right direction in this respect.

One step forward, admittedly small, was the creation in 1975 of a national botanical society. With botany and related fields being pursued in more centres, there was felt a need to supply a forum for professional exchange. The existing Papua New Guinea Scientific Society (which was to cease activity in 1979) was seen as inappropriate and accordingly the Papua New Guinea Botanical Society was formed. It has continued to the present as a 'collaborative': no constitution, no dues, etc., a policy deemed best given local circumstances. Meetings in recent years have been annual, in different centres, and have provided a forum for young Papua New Guinean professionals and subprofessionals, as well as others interested in botany, agriculture, forestry and related areas. But under present circumstances the Society, a confederation, can do little to improve the status of the field, or indeed the sciences, in Papua New Guinea.

It remains to be seen how long an effective publication programme can continue. Several key works did appear in the ten years after independence. The chief of these is the Lae-based project *Handbooks of the Flora of Papua New Guinea*, which I have previously referred to. Established in the early 1970s, this was intended to produce a series of volumes eventually to cover the whole vascular flora of Papuasias, with full treatment of species occurring in Papua New Guinea. By my estimate, some 15,000 species would have to be covered. The first volume appeared in 1978, the second in 1982; so far 25 families (two only in part) and 361 species have been documented. A third volume was ready for press in 1984. I feel that the future of this ambitious flora project is most uncertain.

The period since 1975, however, has been notable for regional revisions and/or handbooks for several large families as well as partial floras. Among the former are treatments of Gramineae (by Ted Henty) and Leguminosae (by Bernard Verdcourt at Kew), both published as *Botany Bulletins*; Euphorbiaceae (by the late Ken Airy Shaw, also at Kew), in *Kew Bulletin, Additional Series*; and Solanaceae (by David Symon, formerly at the Waite Institute in South Australia), in

Journal of the Adelaide Botanic Garden. These joined Josephine Koster's series on the Compositae in *Nova Guinea, Botany and Blumea*. An English edition of Schlechter's *Die Orchidaceen von Deutsch-Neu-Guinea* appeared in Australia in 1982, with the formerly separate plates (published in 1928) incorporated. Recent new or reprinted regional floras/check-lists include Schumann & Lauterbach's flora (by the German publisher Cramer); check-lists for Mt Wilhelm (Johns & Stevens 1971, now out of date), Bougainville (Foreman 1972), and the upper Watut basin in Morobe Province (Streimann 1983); and the translation by Ted Henty of the MS. *Illustrierte Flora des Bismarckarchipels für Naturfreunde*, Father Peckel's legacy of nearly 40 years of work (Peckel 1985). For habitat-related plant groups, two key works have appeared in the last decade: *The alpine flora of New Guinea* (van Royen 1979–1983) and *Freshwater plants of Papua New Guinea* (Leach and Osborne 1985).

We have already mentioned *Biogeography and ecology of New Guinea* (Gressitt 1982), to its credit a truly international effort representing most 'interests'. Although not covering all aspects, the several botanical papers therein provide a fair overview of our present state of knowledge.

All this might suggest that the 'consolidation' phase (van Royen 1980, p. 297), the same as what may also be called the *beta* stage and representing the step from level 5 up to level 4 or even level 3 in Jaeger's map (cf. Frodin 1984, p. 20) is close to fulfillment; but such is in fact far from the case. With some good reason publication of collection catalogues has given way to preparation of revisions, and these latter properly seen as having a wider geographic scope. The work of some individuals and institutes has been guided for four decades by the *Flora Malesiana* project, now about 20% complete at species level (cf. van Steenis 1979; Prance & Campbell 1988). A good portion of the big trees is relatively well known. However, as noted, few have so far been covered in the *Handbooks*. Other current knowledge of the flora remains quite scattered. Many seed plant families, or parts thereof, are for the region scarcely documented in modern terms, with available information sometimes very old and often not helpful. Although in eastern New Guinea the density of collections per 100 square kilometres is now between 40 and 50 — not high but not *really* low — different kinds of plants have *not* been equally well collected (Stevens, pers. comm.), and there are some localities which have been too frequently sampled at the expense of others. Indices of collecting density are at best crude measures. Some research has unfortunately not been published, including a number of *Handbooks* treatments. Such circumstances make it difficult to obtain a good idea of the distribution, abundance and dynamics of most species and hence to provide satisfactory assessments of their conservation status.

Lack of knowledge among cryptogams and fungi is even greater. Despite some revisions, and a start on a students' manual (Johns 1979–1981), much still must be done on the rich pteridophyte flora; and the groups of lower cryptogams and fungi (except those of interest to agriculture and forestry) rarely if ever have had resident workers. Only in the 1970s and 1980s has more attention been paid to some of these groups, and major efforts made to produce modern catalogues: hepatics

(Grolle & Piippo 1984); lichens (Streimann 1986); and mosses (Koponen & Norris, in preparation). Shaw (1984) revised and expanded her compendium of pathogenic fungi and other microorganisms. The four expeditions (1964–1975) from the Tokyo National Science Museum have resulted in several papers covering most cryptogam groups. Marine algae have been studied in the vicinity of the King Leopold Research Station and elsewhere. But these are only a start.

An effective understanding of diversity, however, comes not merely from increasing collecting density or production of general floras or check-lists, however useful they may be. It comes from field study and recognition of meaningful biological entities, an area opened for New Guinea by Wim Vink's analysis of *Drimys* (Vink 1970). Stevens (1989, p. 126) has given other examples. To these I can add *Dracontomelum* (Anacardiaceae) where for Papuasias at least I believe the account in *Flora Malesiana* (Hou 1982) does not reflect the true situation. Similar comments may be made of *Allophylus* and *Pometia* in the Sapindaceae, *Terminalia* in the Combretaceae, and possibly *Intsia* in the Leguminosae. Such studies must pay close attention to local habitat, ecology and floristic differentiation (cf. Ashton 1988). Added to the evidence from primarily herbarium-based studies, they are potentially of real value to informed decisions about land stewardship.

III. Conclusion

I shall close by saying simply that our present state of botanical progress in Papuasias — and it is well advanced — has been, with some notable exceptions, rather more the work of individuals than as part of long-term collective goals. Botany — and, to a greater or lesser extent, other sciences — have had to develop in often limited and unstable political and administrative environments, with weak institutions, few if any policies, and often limited means and outlooks. The lands have moreover suffered the dislocations of administrative changes, war and rebel activities. In recent years priority has gone to problem-solving projects and related research, of which the control of the highly invasive water-fern *Salvinia molesta* in the 1980s provides a good example. But Papuasias is such that flexibility and patience will always be called for. Consolidation and advance of botanical knowledge in the long run remains as necessary and important as it was to Lam 55 years ago, and we must look at further ways to achieve it.

To this end the potential of information systems technology has scarcely begun to be tapped, in part because the effective spread of computers in New Guinea was late. Apart from primary documentation, including a geocological database², its use would be valuable in research on medicinal plants — an area which with some exceptions has not received much attention in the region (Matainaho 1984), in ethnobotany generally (cf. Wasserman 1989), and in improving our understanding of Papuasian vegetation, including its description and classification (cf. Grubb & Stevens 1985; Smith 1987). The last-named

is of particular concern: we still know relatively little of the lowland and upland forests to about 1,500 metres, including those where dipterocarps are significant — yet it is in these zones that extractive logging has been most active. Among the few major studies is one on the Gogol forests by Simon Saulei, now with the Forestry Research Institute in Lae.

In addition to vegetation studies, more attention should also be paid to exploration of unknown or poorly collected areas and the study of taxic differentiation and diversity. Stevens (1989, p. 127) has provided a map of 'well-collected' areas in Papuasias (exclusive of the Solomons) based on about 50 specimens/100 km². But even this density may not be high enough, as we move beyond basic inventory towards the challenges posed by the study of diversity, one of the finest of intellectual pursuits. Improved knowledge of the plants in the field is, moreover, a requisite to informed decisions about conservation, development, and land stewardship.

Ways should also be found to increase local appreciation (and political awareness) of botanical diversity. In basic taxonomy, much more can — and should — be done at the grass roots, providing 'stepping stones' rather than 'dream edifices' (Ng 1988). The students' manuals of Johns represent such stepping stones, as do present and future local floras and check-lists. There remains room, however, for responsible, long-term collaboration: the needs are, and likely will remain for some time, too much for the Papua New Guineans in the field to handle unaided. It will not be easy, for the body of interested and active persons is small, and has shrunk in the last decade or so. Papua New Guinea and its neighbours continue to develop, however, and there is always opportunity for more initiatives, especially with new or renewed institutions such as the Forest Research Institute.

Acknowledgements

I thank the people of Papua New Guinea as well as the Division of Botany, Lae, and the University of Papua New Guinea, Port Moresby, for the opportunity to have spent sixteen years working and teaching in that country, as well as many individuals there, in Australia and elsewhere for information and advice over the years. I also express my gratitude to the Australian Systematic Botany Society for inspiring this paper and making it possible for me to present it in Australia on the occasion of the Symposium. My father, Reuben Frodin, kindly read an earlier draft. I dedicate it to all past and future botanical explorers in Papuasias, as well as to the late Dr J. Linsley Gressitt, my co-author in a historical survey written for *Biogeography and ecology of New Guinea*.

References

- Alexander, F. (1972). *Australia since Federation*. (Nelson: Melbourne).
- Allied Geographical Section (1943). *Vegetation study of eastern New Guinea*. (Melbourne).
- Angus, R. J. B. (1972). Forestry. In P. Ryan (ed.), *Encyclopaedia of Papua and New Guinea*. Vol. 1. (Melbourne Univ. Press/Univ. of Papua New Guinea: Melbourne). pp. 447–463.
- Ashton, P. S. (1988). Systematics and ecology of rain forest trees. *Taxon* 37: 622–29.
- Australia: Department of National Development (1951). *The resources of the Territory of Papua and New Guinea*. 2 parts. (Govt Printer: Melbourne).
- Australia: Parliament (1907). *British New Guinea: report of the royal commission of inquiry into the present conditions, including the method of government of the Territory of Papua, and the best means for their improvement*. (Parliamentary Papers, 1907.) (Acting Govt Printer: Melbourne).
- Balgooy, M. M. J. van (1976). Phytogeography. In Pajmans, K.

² The Department of Agriculture and Livestock now has a Resource Information System (PNGRIS) Unit.

- (ed.). *New Guinea vegetation*. (CSIRO/Australian National Univ.: Canberra), pp. 1–22. Beccari, O. (1877–90). *Malesia*. 3 vols. (Firenze).
- Behrmann, W. (1925). Die deutsche wissenschaftliche Erforschung Neuguineas. In [Zastrow, B. von (ed.)], *Verhandlungen des Deutschen Kolonialkongresses 1924 zu Berlin*. (Kolonialkriegerdank: Berlin), pp. 473–481.
- Bolton, G. C. (1972). *A thousand miles away: a history of North Queensland to 1920*. (Australian National Univ. Press: Canberra).
- Brass, L. J. (1941). The 1938–39 expedition to the Snow Mountains, Netherlands New Guinea. *J. Arnold Arbor.* 22: 271–342, 7 pl.
- Broekway, L. (1979). *Science and colonial expansion: the role of the British Royal Botanic Gardens*. (Academic Press: New York).
- Brongersma, L. D. & Venema, G. F. (1962). *To the mountains of the stars*. Transl. A. G. Readett. (Hodder & Stoughton: London).
- Burcham, L. T. (1948). Observations on the grass flora of certain Pacific islands. *Contr. U.S. Natl. Herb.* 30: 405–447.
- Carter, A. M. (1982). The itinerary of Mary Strong Clemens in Queensland, Australia. *Contr. Univ. Mich. Herb.* 15: 163–169.
- Conn, B. J. (1979). *Botany*. (Dept Forests, Forestry College, Training manual 12.) (Bulolo).
- Corner, E. J. H. (organizer) (1969). A discussion of the results of the Royal Society Expedition to the British Solomon Islands Protectorate, 1965. *Philos. Trans., Ser. B* 255: 185–631.
- Croft, J. R. (1983). An historical survey of botanical exploration in the Admiralty Islands, Manus Province, Papua New Guinea. *Sci. New Guinea* 10: 1–15.
- D'Espey, J. L. (1940). The timber industry in the Territory of New Guinea. *Austral. Forest.* 5: 33–36. [Quoted from summary in *Trop. Woods* 66: 44–46 (1941)].
- Denoan, D. & Snowden, C. (eds.) ([1981]). *A time to plant and a time to uproot: a history of agriculture in Papua New Guinea*. (Inst. of Papua New Guinea Studies: [Port Moresby]).
- Diels, L. (1921). Die pflanzengeographische Stellung der Gebirgsflora von Neu-Guinea. *Bericht der Freien Vereinigung für Pflanzengeographie und systematische Botanik für das Jahr 1919*. (Lande: Berlin), pp. 45–59.
- Division of Botany, Department of Forests, Papua New Guinea (1969–). *Botany Bull.* 1–. Irregular. (Lae).
- Firth, S. (1982). *New Guinea under the Germans*. (Melbourne Univ. Press: Melbourne).
- Fitzpatrick, K. (1958). *Australian explorers*. (Oxford Univ. Press: London). (The world's classics 559.)
- Flenley, J. R. (1979). *The equatorial rain forest: a geological history*. (Butterworths: London).
- Foreman, D. (1972). *A check list of the vascular plants of Bougainville, with descriptions of some common forest trees*. (Div. Botany, Dept Forests, Botany Bull. 5.) (Lae).
- Frodin, D. G. (1981). Too much, too soon: botany in British New Guinea, 1871–1914. *XIII. International Botanical Congress (Sydney, 1981), Abstracts*. (Sydney), p. 194.
- Frodin, D. G. (1984). *Guide to standard floras of the world*. (Cambridge Univ. Press: Cambridge).
- Frodin, D. G. (1985). Herbaria in Papua New Guinea and nearby areas. In Sohmer, S. H. (ed.), *Forum on systematic resources in the Pacific*. (Bernice P. Bishop Mus. Spec. Publ. 74.) (Bishop Museum Press: Honolulu), pp. 54–62.
- Frodin, D. G. (1988). The natural world of New Guinea: hopes, realities and legacies. In MacLeod, R. & Rehbock, P. F. (eds.), *Nature in its greatest extent: Western science in the Pacific*. (Univ. of Hawaii Press: Honolulu), pp. 89–138.
- Frodin, D. G. & Gressitt, J. L. (1982). Biological exploration in New Guinea. In Gressitt, J. L. (ed.), *Biogeography and ecology of New Guinea*, pp. 87–130.
- Frodin, D. G. & Leach, G. J. (1982). *Mangroves of the Port Moresby region*. Rev. ed. (Dept Biology, Univ. Papua New Guinea, Occ. Pap. 3.) (Port Moresby).
- Frodin, D. G. et al. (1975). *Mangroves of the Port Moresby region*. (Dept Biology, Univ. Papua New Guinea, Occ. Pap. 3.) (Port Moresby).
- Gibbs, L. S. (1917). *Dutch N.W. New Guinea, A contribution to the flora and phytogeography of the Arfak Mountains*. (Taylor & Francis: London).
- Good, R. d'O. (1960). On the geographical relationships of the angiosperm flora of New Guinea. *Bull. Brit. Mus. [Nat. Hist.], Bot.* 2(8): 205–226.
- Goode, J. (1977). *Rape of the Fly*. (Nelson: West Melbourne).
- Grattan, C. H. (1963). *The Southwest Pacific before 1900*. (Univ. Michigan Press: Ann Arbor).
- Gressitt, J. L. (ed.) (1982). *Biogeography and ecology of New Guinea*. 1 vol. in 2. (Monogr. Biol. 42.) (Junk: The Hague).
- Grolle, R. & Piiippo, S. (1984). Annotated catalogue of Western Melanesian bryophytes, I. Hepaticae and Anthocerotae. *Acta Bot. Fenn.* 125: 1–86.
- Grubb, P. J. & Stevens, P. F. (1985). *The forests of the Fatima Basin and Mt Kerigomna, Papua New Guinea with a review of montane and subalpine rainforests in Papuasia*. (Australian National Univ., Res. School Pacific Studies, Dept Biogeography & Geomorphology, Publ. BG/5.) (Bibliotech, Anutech: Canberra).
- Hahl, A. (1980). *Governor in New Guinea*. (Australian National Univ. Press: Canberra). [Translated by P. Sack and D. Clark from 1937 edn, *Gouverneursjahre in Neuguinea* (Frundsberg: Berlin)].
- Hartley, T. G. et al. (1973). A survey of New Guinea plants for alkaloids. *Lloydia* 36: 217–319.
- Hasluck, P. (1976). *A time for building*. (Melbourne Univ. Press: Melbourne).
- Havel, J. J. (1970–1975). *Forest botany*. 2 parts. (Dept Forests, Forestry College, Training Manual 3.) (Bulolo).
- Hemsley, W. B. et al. (1899). Flora of British New Guinea. *Bull. Misc. Inform. (Kew)* 1899: 95–126.
- Henty, E. E. (undated). The Division of Botany. Unpublished typescript. Div. Botany, Dept Forests, Lae.
- Hepper, F. N. (1982). *Kew: gardens for science and pleasure*. (Her Majesty's Stationery Office: London).
- Hiepko, P. & Schultze-Motel, W. (1981). Floristische und ethnobotanische Untersuchungen im Eipomek-Tal, Irian Jaya (West-Neuguinea), Indonesien. In Helfrich, K., et al. (eds.), *Schriftreihe Mensch, Kultur und Umwelt in zentralen Bergland von West-Neuguinea*, Beitr. 7. (Reimer: Berlin).
- Hou, D. (1978). Anacardiaceae. In Steenis, C. G. G. J. van (ed.), *Flora Malesiana*, Ser. I, Vol. 8. (Sijthoff & Noordhoff: Alphen a/d Rijn), pp. 395–548.
- Howie-Willis, I. (1978). *A thousand graduates: conflict in university development in Papua New Guinea, 1961–1976*. (Pacific Res. Monograph 3.) (Australian National Univ.: Canberra).
- International Bank for Reconstruction and Development [K. R. Iverson et al.] (1965). *The economic development of the Territory of Papua and New Guinea*. (Johns Hopkins Univ. Press: Baltimore).
- Jacobs, M. (1984). *Hermann Johannes Lam (1892–1977), the life and work of a Dutch botanist*. (Rhodopi: Amsterdam).
- Johns, R. J. (1976–1978). *Common forest trees of Papua New Guinea*. 13 parts. (Dept Forests, Forestry College, Training manual 8.) (Bulolo).
- Johns, R. J. (1979–1981). *The ferns and fern allies of Papua New Guinea*. Parts 1–12 (in 2 fascicles). (Lae). [Parts 6–12 published as Papua New Guinea Univ. of Technology Res. Rep. 48–81.]
- Johns, R. J. (1986). The instability of the tropical ecosystem in New Guinea. *Blumea* 31: 341–371.
- Johns, R. J. & Stevens, P. F. (1971). *Mount Wilhelm flora: a check list of the species*. (Div. Botany, Dept Forests, Botany Bull. 6.) (Lae).
- Johns, R. J. & Hay, A. [1981]. *A student's guide to the monocotyledons of Papua New Guinea*. Part 1. (Dept Forests, Forestry College, Training manual 13.) (Bulolo).
- Johns, R. J. & Hay, A. J. M. (eds) (1984). *A guide to the monocotyledons of Papua New Guinea*. Parts 2–4. (L. J. Brass Memorial Herbarium, Forestry Dept, Papua New Guinea Univ. of Technology: Lae).
- Kajewski, S. F. (1946). Botanizing in the British Solomon Islands. *J. Arnold Arbor.* 27: 292–304.
- Kanehira, R. et al. (1941–43). The Kanehira-Hatusima 1940 collection of New Guinea plants. I–XXI. *Bot. Mag. (Tokyo)* 55–57, passim.
- King, G. A. & Bull, P. B. (1984). The Papua New Guinea Biological Foundation banana collection. *IBPGR Regional Committee for Southeast Asia Newsl. 8*(2): 3–4.
- Klein, W. C. (coord.) (1935–38). *Nieuw-Guinee*. 3 vols. (Molukken-Instituut: Amsterdam).
- Kobayasi, Y. (1971). Preface. In idem (compil.), *Mycological reports from New Guinea and the Solomon Islands*, 1–11. *Bull. Natl. Sci. Mus. Tokyo* 14: 367–372, 545–551, 2 pl.
- Kraemer, J. H. (1951). *Trees of the Western Pacific region*. (Tri-State Offset Co.: West Lafayette, Indiana).

- Kynaston, E. (1981). *A man on edge*. (Allen Lane/Penguin: Ringwood, Victoria).
- Lack, H. W. (1987a). Opera magna in Berlin plant taxonomy. *Englera* 7: 253–281.
- Lack, H. W. (1987b). Botanik und Zoologie. In Buddensieg, T., Duewel, K. & Sembach, K.-J. (eds.), *Wissenschaften in Berlin: Disziplinen*. (Mann: Berlin). (Sonderdruck, pp. 1–8.)
- Lam, H. J. (1927–29). Fragmenta papuana. *Natuurk. Tijdschr. Ned. Indië* 87–89, passim.
- Lam, H. J. (1934). Materials towards a study of the flora of the island of New Guinea. *Blumca* 1: 115–159.
- Lam, H. J. (1935). De vegetatie en de flora van Nieuw Guinee. In W. C. Klein (coord.), *Nieuw Guinee*, Vol. 1. pp. 187–210, fig. 36–43, map.
- Lam, H. J. (1945). Fragmenta papuana. *Transl. Lily M. Perry. Sargentia* 5: 1–196.
- Lam, H. J. (1960). Het botanisch onderzoek van Nieuw-Guinea in verleden, heden en toekomst. *Schakels/Nederlands Nieuw Guinea* 38: 9–27, map.
- Lam, H. J. (1961). Botanical exploration of New Guinea in the past, present and future. *Schakels/Nederlands Nieuw Guinea* 44: 9–27.
- Lambley, P. W., & Frodin, D. G. (1987). The Natural Sciences Resource Centre at the University of Papua New Guinea. *Curator* 30: 250–258.
- Lane-Poole, C. E. (1925). *The forest resources of the territories of Papua and New Guinea*. (Australia, Parl. Papers, 1925.) (Govt Printer: Melbourne).
- Lang, J. D. (1871). New Guinea — a highly promising field for settlement and colonization, and how such an object might be most easily and successfully effected. *Trans. & Proc. Roy. Soc. New South Wales* (1871): 35–47.
- Langdon, R. F. (1981). The remarkable Mrs Clemens. In Carr, D. J. & Carr, S. G. M. (eds), *People and plants in Australia*. (Academic Press: Sydney).
- Lauterbach, C. (1910). Vegetationskarte von Kaiser-Wilhelms-Land und Bismarck-Archipel. In Meyer, H. (ed.), *Das deutsche Kolonialreich*, Bd. 2: Togo, Südwestafrika, Schutzgebiete in der Suedsee und Kiantschougebiet. Map and pp. [i]–[iii] in appendices following W. Sievers, Die Schutzgebiete in der Suedsee.
- Lauterbach, C. (1911). Neuere Ergebnisse der pflanzengeographischen Erforschung Neu-Guineas. *Bot. Jahrb. Syst.* 45, Beiblatt 103: 23–27.
- Leach, G. J. & P. L. Osborne (1985). *Freshwater plants of Papua New Guinea*. (Univ. Papua New Guinea Press: Port Moresby).
- Mackellar, C. D. (1912). *Scented isles and coral gardens*. (Murray: London).
- Macmillan, D. S. (1957). *A squatter went to sea*. (Currawong: Sydney).
- Maiden, J. H. (1923). A botanical bibliography of the Pacific Islands. In Lightfoot, G. (ed.), *Proceedings of the Pan-Pacific Science Congress, Australia, 1923*, Vol. 1. (Sydney). pp. 293–297.
- Matainaho, T. (1984). Traditional medicine (medicinal plants): is there a scientific basis? In Morton, J. R. (ed.), *The role of science and technology in the development of Papua New Guinea: the policy dimensions*. Vol. 1. pp. 29–33.
- Merrill, E. D. (1945). *Plant life of the Pacific world*. (Macmillan: New York).
- Meyer, G. (1977). German interests and policy in the Netherlands East Indies and Malaya, 1870–1914. In Moses, J. A. & Kennedy, P. M. (eds), *Germany in the Pacific and Far East 1870–1914*. (Univ. Queensland Press: St. Lucia, Queensland). pp. 40–58.
- Meyer, H. (ed.) (1910). *Das deutsche Kolonialreich*. Bde. 1–2 in 2 vols. (Bibliographisches Institut: Leipzig/Wien).
- Michener, J. A. (1951). *Return to paradise*. (Secker & Warburg: London). (Corgi Books edition, 1967.)
- Millar, A. (1978). *Orchids of Papua New Guinea: an introduction*. (Australian National Univ. Press: Canberra).
- Miquel, F. A. W. (1855–1859). *Flora van Nederlandsch Indië/Floraë indiae batavae*. 3 vols. in 4. (van der Post: Amsterdam).
- Mitchell, A. W. (1986). *The enchanted canopy*. (Macmillan: New York).
- Moresby, J. (1876). *Discoveries and surveys in New Guinea and the d'Entrecasteaux*. (Murray: London).
- Morton, J. R. (ed.) (1984). *The role of science and technology in the development of Papua New Guinea: the policy dimensions*. 3 vols. (Faculty of Science, Univ. Papua New Guinea: Port Moresby).
- Mueller, F. J. H. (1875–1890). *Descriptive notes on Papuan plants*. 9 parts. (Govt Printer: Melbourne).
- Mueller, F. J. H. (1875). *Descriptive notes on Papuan plants*. Part 1, pp. 1–16.
- Mueller, F. J. H. (1876). *Descriptive notes on Papuan plants*. Part 4, pp. 51–82.
- Mueller, F. J. H. (1889). Record of observations on Sir William MacGregor's highland-plants from New Guinea. *Trans. Roy. Soc. Victoria* 1(2): 1–45.
- Mueller, F. J. H. (1890). Highland plants from New Guinea. *Nature* 42: 382–383.
- Mueller, F. J. H. (1890). Some scientific results of Sir William MacGregor's recent expedition to the Owen-Stanley Range. *Proc. Roy. Geogr. Soc.*, n.s. 12: 103–110.
- Nelson, H. (1982). *Taim bilong masta*. (Australian Broadcasting Commission: Sydney).
- Ng, F. S. P. (1988). Problems in the organization of plant taxonomy work. *Austral. Syst. Bot. Newslett.* 54: 6–12. [Also publ. in *Fl. Males. Bull.* 10: 39–44, September 1988.]
- [Oliphant, M. L. (ed.)] (1952). *Science in Australia*. (Cheshire: Melbourne).
- Paijmans, K. (ed.) (1976). *New Guinea vegetation*. (CSIRO/Australian National Univ. Press: Canberra).
- Papua New Guinea Department of Forests (1973). *New horizons*. (Jacaranda: Brisbane).
- Peckel, P. G. (1985). *Flora of the Bismarck Archipelago for naturalists*. Transl. E. E. Henty. (Div. Botany, Office of Forests: Lae).
- Pernetta, J. C. & Hill, L. (1984). The role of indigenous professional scientists and scientific organisations in the development of the Pacific Region: with emphasis on Papua New Guinea. In Morton, J. R. (ed.), *The role of science and technology in the development of Papua New Guinea: the policy dimensions*. Vol. 2. pp. 158–184.
- Potter, D. J. (1984). Subsistence agricultural research and policy. In Morton, J. R. (ed.), *The role of science and technology in the development of Papua New Guinea: the policy dimensions*. Vol. 3. pp. 1–29.
- Prance, G. T., & Campbell, D. G. (1988). The present state of tropical floristics. *Taxon* 37: 519–548.
- Pyenson, L. (1988). *Empire of reason: exact sciences in Indonesia 1840–1940*. (Brill: Leiden). (Brill's studies in intellectual history 13.)
- Reeder, J. R. (1948). The Gramineae-Panicoideae of New Guinea. *J. Arnold Arbor.* 29: 257–392.
- Rendle, A. B. et al. (1923). Dr H.O. Forbes's New Guinea plants. *J. Bot.* 61, Suppl.: 1–64.
- Rendle, A. B. et al. (1924–1926). Dr H. O. Forbes's Malayan plants. *J. Bot.* 62–64, Suppl.: 1–149.
- Richard, A. (1834). *Sertum astrolabianum*. In Dumont d'Urville, J.S.C., *Voyage de decouvertes de l'Astrolabe, Botanique*. 2. partie. (Tastu: Paris).
- Ridley, H. N. (1886). On the monocotyledonous plants of New Guinea collected by Mr H. O. Forbes. *J. Bot.* 24: 321–327, 353–360.
- Ridley, H. N. (1916). Report on the botany of the Wollaston Expedition to Dutch New Guinea, 1912–13. *Trans. Linn. Soc. London, Bot.* 9: 1–269, 6 pl.
- Robide van der Aa, P. J. B. C. (1879). *Reizen naar Nederlandsch Nieuw-Guinea*. (s'Gravenhage).
- Royen, P. van (1963). *The vegetation of the island of New Guinea*. (Div. Botany, Dept Forests: Lae).
- Royen, P. van (1979–1983). *The alpine flora of New Guinea*. 4 vols. (Cramer/Gartner: Vaduz).
- Royen, P. van (1980). *The alpine flora of New Guinea*. Vol. 1, General Part. (Cramer/Gartner: Vaduz).
- Royen, P. van et al. (1964–1969). *Manual of the forest trees of Papua and New Guinea*. 9 parts (pt. 1 in 2 editions). (Div. Botany, Dept Forests: Lae).
- Ryan, P. (1972). World War II. In Ryan, P. (ed.), *Encyclopaedia of Papua and New Guinea*. Vol. 2. (Melbourne Univ. Press/Univ. Papua New Guinea: Melbourne). pp. 1211–1224.
- Salter-Duke, B. J. (1984). A role for scientific societies in Papua New Guinea. In Morton, J. R. (ed.), *The role of science and technology in the development of Papua New Guinea: the policy dimensions*. Vol. 3. pp. 110–122.
- Schlechter, R. (1911–1914). *Die Orchidaceen von Deutsch-Neu-Guinea*. (Repert. Spec. Nov. Regni Veg. [Fedde], Beih. 1.) (Verlag des Repertoriums: Berlin-Dahlem).

- Schlechter, R. (1982). *The Orchidaceae of German New Guinea (incorporating the Figure Atlas to the above)*. (The Australian Orchid Foundation: Melbourne).
- Schumann, K. (1898). Die Flora von Neu-Pommern. *Notizbl. Koenigl. Bot. Gart. Berlin* 2: 59–158.
- Schumann, K., & Hollrung, U. M. (1889). *Die Flora von Kaiser-Wilhelms-Land*. (Asher: Berlin).
- Schumann, K., & Lauterbach, K. (1900). *Die Flora der deutschen Schutzgebiete in der Suedsee*. (Borntraeger: Leipzig).
- Schumann, K., & Lauterbach, K. (1905). *Nachtraege zur Flora der deutschen Schutzgebiete in der Suedsee (mit Ausschluss Samoa's und der Karolinen)*. (Leipzig).
- Shaw, D. E. (1963). *Plant pathogens and other microorganisms in Papua and New Guinea*. (Dept Agric. Stock Fisheries Res. Bull. 1.) (Port Moresby).
- Shaw, D. E. (1984). *Microorganisms in Papua New Guinea*. (Dept Primary Industry Res. Bull. 33.) (Port Moresby).
- Shurcliff, S. N. (1930). *Jungle islands: the Illyria in the South Seas*. (Putnam's: New York).
- Sievers, W. (1910). Die Schutzgebiete in der Suedsee. In H. Meyer (ed.), *Das deutsche Kolonialreich, Bd. 2: Togo, Suedwestafrika, Schutzgebiete in der Suedsee und Kiautschougebiet*, pp. 299–496. [Deutsch-Melanesien, pp. 394–462.]
- Sinclair, J. (1978). *Wings of gold*. (Pacific Publications: Sydney).
- Šlaus, I. (1987). Science in a peripheral country: a personal perception. *ESF Communications* 16: 3–18.
- Smith, J. M. B. (1987). [Review of] Grubb, P. J., & Stevens, P. F. *The forests of the Fatima Basin and Mt. Kerigomna ... Austral. J. Ecol.* 12: 205–206.
- Souter, G. (1964). *New Guinea: the last unknown*. (Angus & Robertson: Sydney).
- Steenis, C. G. G. J. van (1934–1936). On the origin of the Malaysian mountain flora, I–III. *Bull. Jard. Bot. Buitenzorg*, ser. III, 13: 135–262, 289–417; 14: 56–72.
- Steenis, C. G. G. J. van (ed.) (1948–). *Flora Malesiana*, ser. I. Vols. 1, 4–. (Noordhoff: Jakarta/Groningen, etc.; at present Nijhoff: The Hague).
- Steenis, C. G. G. J. van (1979). The Rijksherbarium and its contribution to the knowledge of the tropical Asiatic flora. *Blumea* 25: 57–77.
- Steenis, C. G. G. J. van (1982). Dedication [to Odoardo Beccari]. In idem (ed.), *Flora Malesiana*, ser. I, vol. 9, pp. (6)–(44). (Nijhoff: The Hague).
- Steenis-Kruseman, M. J. van (1950–1974). Malaysian plant collections and collectors [with Supplements I, II]. In Steenis, C. G. G. J. van (ed.), *Flora Malesiana*, ser. I, Vols. 1, 5, 8. (Repr. 1985 in 1 vol.; Koeltz: Koenigstein/Taunus).
- Steenis-Kruseman, M. J. van (1950). Malaysian plant collections and collectors. In Steenis, C. G. G. J. van (ed.), *Flora Malesiana*, ser. I, Vol. 1. (Noordhoff-Kolff: Djakarta).
- Steenis-Kruseman, M. J. van (1958). Malaysian plant collections and collectors: Supplement I. In Steenis, C. G. G. J. van (ed.), *Flora Malesiana*, ser. I, Vol. 5, pp. [1]–[108]. (Noordhoff: Groningen).
- Stevens, P. F. (1989). Floristic inventory of New Guinea. In Campbell, D. G., & Hammond, D. (eds.). *Floristic inventory of tropical countries*. (The New York Botanical Garden: New York), pp. 120–132.
- Streimann, H. (1983). *The plants of the Upper Watut Watershed of Papua New Guinea*. (National Botanic Gardens: Canberra).
- Streimann, H. (1986). *Catalogue of the lichens of Papua New Guinea and Irian Jaya*. (Cramer/Gantner: Vaduz).
- Sutton, S. B. (1970). *Charles Sprague Sargent and the Arnold Arboretum*. (Harvard Univ. Press: Cambridge, Mass.).
- Thompson, R. C. (1980). *Australian imperialism in the Pacific*. (Melbourne Univ. Press: Melbourne).
- Tideman, J. (1935). Algemeene inleiding. In Klein, W. C. (ed.), *Nieuw-Guinee*, Vol. 1, pp. 3–17.
- Timler, F. K., & Zepernick, B. (1987). German colonial botany. *Ber. Deutsch. Bot. Ges.* 100: 143–168.
- Veldkamp, J. F., Vink, W., & Frodin, D. G. (1988). Ledermann's and some other German localities in Papua New Guinea. *Fl. Males. Bull.* 10: 32–38.
- Vink, W. (1965). Botanical exploration of the Arfak Mountains. *Nova Guinea, Bot.* 22: 471–494, pl. 42–46.
- Vink, W. (1970). The Winteraceae of the Old World, I. *Pseudowintera* and *Drimys*: morphology and taxonomy. *Blumea* 18: 225–354.
- Wagner, W. H., Jr. & Grether, D. F. (1948). Pteridophytes of the Admiralty Islands. *Univ. Calif. Publ. Bot.* 23: 17–109, pl. 5–25.
- Walker, D. (ed.) (1972). *Bridge and barrier*. (Australian National Univ., Res. School of Pacific Studies, Dept Biogeography & Geomorphology, Publ. BG/3.) (Australian National Univ.: Canberra).
- Walker, E. H. (1945). Natural history in the armed forces: a resume of some recent literature, mostly botanical, of interest to servicemen. *Sci. Month.* 61: 307–312.
- Walker, E. H. (1946). Biological collecting during World War II. *Sci. Month.* 63: 333–340.
- Walker, F. S. (1948). *The forests of the British Solomon Islands Protectorate*. (Crown Agents: London). 186 pp. 21 maps.
- Warburg, O. (1891). Beitrage zur Kenntnis der papuanischen Flora. *Bot. Jahrb. Syst.* 13: 230–455.
- Warburg, O. (1892). Die Vegetationsverhaeltnisse von Neu-Guinea. *Verh. Ges. Erdk. Berlin* 1892: 130–147.
- Warburg, O. (1900). *Monsunia*. Vol. 1. (Berlin). [All publ.]
- Webb, L. J. (1955). A preliminary phytochemical survey of Papua-New Guinea. *Pacific Sci.* 9: 430–441.
- Wasserman, S. (1989). Future pharmaceuticals. *Computerland Mag.* 4(2): 20–23, 44.
- Webb, L. J. (1977). *Ecological considerations and safeguards in the modern use of tropical lowland rain forests as a source of pulpwood: example, the Madang Area, PNG*. (Office of Environment & Conservation, Dept Natural Resources, PNG: Port Moresby).
- White, C. T. (1922). A contribution to our knowledge of the flora of Papua (British New Guinea). *Proc. Roy. Soc. Queensland* 34: 5–65.
- White, C. T. (1950). Ligneous plants from the Solomon Islands (and New Guinea). *J. Arnold Arbor.* 31: 81–116.
- White, C. T. et al. (1929). Ligneous plants collected in the Territory of Papua in 1925–1926 by L. J. Brass. *J. Arnold Arbor.* 10: 197–274.
- Whitmore, T. C. (1966). *Guide to the forests of the British Solomon Islands*. (Oxford Univ. Press: London).
- Wichmann, A. (1909–1912). *Entdeckungsgeschichte von Neu-Guinea*. (Nova Guinea, vols. 1–2.) (Brill: Leiden).
- Winkler, H. (1938). Carl Lauterbach. *Ber. Deutsch. Bot. Ges.* 55: (231)–(247).
- Wit, H. C. D. de (1949). Short history of the phytography of Malaysian vascular plants. In Steenis, C. G. G. J. van (ed.), *Flora Malesiana*, ser. I, Vol. 4, pp. lxxi–elxi.
- Womersley, J. S. (1953). A brief history of botanical exploration of Papua and New Guinea. *Papua and New Guinea Agric. Gaz.* 8(2): 32–39.
- Womersley, J. S. & McAdam, J. B. (1957). *The forests and forest conditions in the territories of Papua and New Guinea*. ([Dept Forests, Territory of Papua & New Guinea.]: n.p.) [Reprinted 1975.]
- Womersley, J. S. et al. (eds) (1978–). *Handbooks of the flora of Papua New Guinea*. Vols. 1–. (Melbourne Univ. Press: Melbourne).
- Yeboah-Amankwah, D. (1984). Why science in Papua New Guinea. In Morton, J. R. (ed.), *The role of science and technology in the development of Papua New Guinea: the policy dimensions*. Vol. 1, pp. 1–13.
- Zollinger, H. (1857). Ueber den Begriff und Umfang einer 'Flora Malesiana'. *Vierteljahrsschr. Naturf. Ges. Zürich* 2: 317–349, map.